Haida Gwaii

TIMBER SUPPLY REVIEW

Data package 2011

November 8, 2011

Submitted by: Joint Technical Working Group

Submitted to: Haida Gwaii Management Council and Jim Snetsinger, Chief Forester

Contents

This data package represents the data and approaches used to date in the analysis. However, input is still invited so that any warranted corrections can be made and/or appropriate analysis undertaken to ensure the Haida Gwaii Management Council and Chief Forester have the best available information to make their AAC determinations.

1.0 Introduction

The Haida Gwaii Strategic Land Use Agreement (SLUA) and associated Land Use Objectives Orders (LUOOs) form the basis for defining current management for the purposes of developing inputs for timber supply analysis. The SLUA and LUOO are assumed to incorporate Haida and provincial interests with respect to land use and management.

The Council of the Haida Nation (CHN) has an interest in seeing that all of Haida Gwaii is treated as a management unit subject to consistent, sustainable management across tenure boundaries; that timber harvests on Haida Gwaii translate into better quality of life for people on the islands; and that the analysis incorporates reasonable expectations of timber growth rates and quality and provides information useful for assessing economic viability of harvesting timber in different areas and forest types on Haida Gwaii.

This Timber Supply Review has been directed by a unique process for Haida Gwaii in that the technical process has been collaboratively undertaken by the CHN and Province of British Columbia (BC) as a result of the Kunst'aa guu – Kunst'aayah, or Haida Gwaii Reconciliation Protocol. Similarly, the decision making process is directed by the *Haida Gwaii Reconciliation Act* and KaayGuu Ga ga Kyah ts'as - Gin 'inaas 'laas 'waadluwaan gud tl'a gud giidaa (Haida Stewardship Law)which delegates authority to the Haida Gwaii Management Council for annual allowable cut determinations.

The analysis for this Timber Supply Review has been undertaken utilizing a spatially explicit, volume-based harvest forecasting model and includes information for the entire operating land base of Haida Gwaii, including the Timber Supply Area (TSA 25), and Tree Farm Licenses (TFLs) 58 and 60. Analysis is being undertaken to support two sets of allowable annual cut (AAC) determinations: one by the Haida Gwaii Management Council (HGMC) for all of Haida Gwaii; and the second by the provincial Chief Forester, consisting of separate determinations for the Timber Supply Areas and both Tree Farm Licenses on Haida Gwaii. The *Haida Gwaii Reconciliation Act* requires that the Chief Forester determinations, plus AAC determinations for other management units like woodlot licenses and First Nations Woodland Tenure, not exceed the overall level determined by the HGMC.

This version of the data package includes revisions made based on a review of forest industry licensees with tenures on Haida Gwaii.

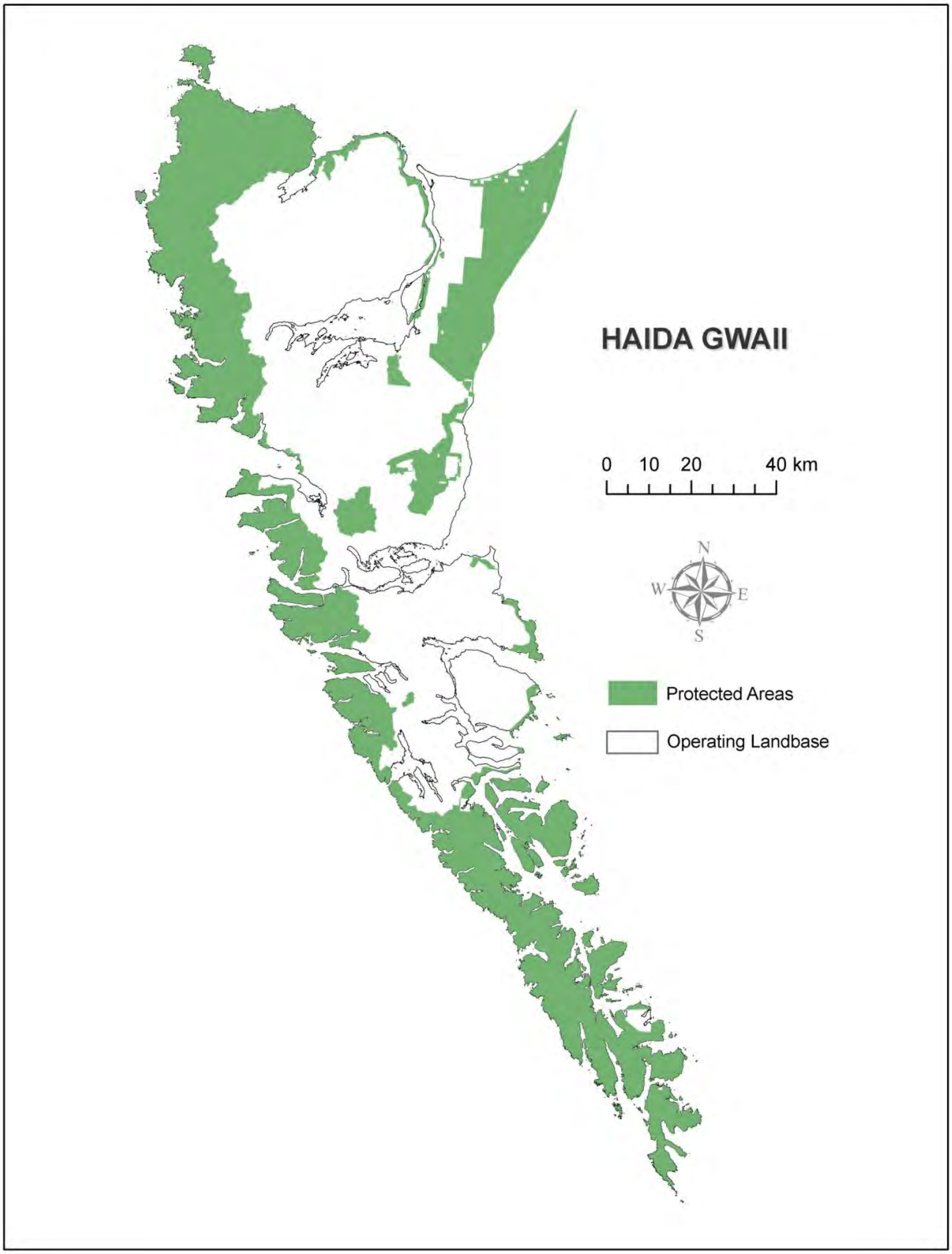


FIGURE 1: MAP OF HAIDA GWAII

2.0 Inventory and model files

See appendix 3 for a complete list of inventory and model files.

3.0 Exclusions from the Timber Harvesting Land Base (THLB)

TABLE 1: HAIDA GWAII TIMBER HARVESTING LAND BASE DEFINITION

Haida Gwaii Netdown	GROSS REDUCTIONS	NET REDUCTIONS	NET AFTER REDUCTIONS
Management Unit	TOTAL	TOTAL	TOTAL
Gross Area			1,006,310
Lakes, Wetlands, Rivers	63,987	63,987	942,323
Non Productive	130,467	109,884	832,439
Non Forested	4,923	4,919	827,519
No Typing Available	24,566	23,825	803,694
No Species Info in Inventory	29,419	6,554	797,140
Conservancies	271,804	203,359	593,781
Non-forest management administration	245,876	195,511	398,270
Terrain Stability Classes 4 and 5	54,292	33,452	364,818
Economically Inoperable	85,644	22,764	342,054
Cedar Stewardship Areas	22,829	20,098	321,956
Forest Reserve Network	34,088	22,301	299,655
Wildlife Habitat Areas	1,717	255	299,400
Active Fluvial Units	30,749	9,290	290,110
Forested Swamps	14,278	663	289,447
Saw-whet Owl and Goshawk	3,225	1,550	287,898
Potential Goshawk Habitat*	4,771	3,100	284,798
Potential Blue Heron Nesting*	208	76	284,722
Red Listed Site Series	12,408	1,801	282,922
Blue Listed Site Series	97,295	14,513	268,409
Riparian Buffers	255,213	60,703	207,706
Not Sufficiently Restocked	11,822	1	207,705
In Block Reductions (Monumental Cedar 13.7%, CMTs 7.7%, HTFF 5%)	46,463	10,363	197,342
Future Roads Trails and Landings	12,733	8,623	188,718

Note *: In preparation of the base case data set, the exclusions for potential goshawk habitat and potential blue heron nesting sites were not made. Therefore, **the base case timber harvest land base inadvertently included those areas and was consequently 1.16% larger that shown (or 190,907 ha) for Haida Gwaii as a whole**. This magnitude of difference is not highly consequential for timber supply given the level of uncertainties surrounding other factors; however, this difference will be highlighted to the appropriate decision makers during AAC determination processes.

TABLE 2: TSA 25 TIMBER HARVESTING LAND BASE DEFINITION

Haida Gwaii Netdown	GROSS REDUCTIONS	NET REDUCTIONS	NET AFTER REDUCTIONS
Management Unit	TSA25	TSA25	TSA25
Gross Area			798,301
Lakes, Wetlands, Rivers	57,863	57,863	740,438
Non Productive	104,467	84,334	656,104
Non Forested	2,707	2,707	653,396
No Typing Available	22,367	22,015	631,381
No Species Info in Inventory	25,702	4,137	627,244
Conservancies	228,325	177,884	449,361
Non-forest management administration	236,014	187,428	261,933
Terrain Stability Classes 4 and 5	41,384	21,914	240,019
Economically Inoperable	85,004	22,444	217,575
Cedar Stewardship Areas	10,998	9,835	207,739
Forest Reserve Network	20,467	11,659	196,080
Wildlife Habitat Areas	1,477	255	195,826
Active Fluvial Units	16,171	4,627	191,199
Forested Swamps	13,639	399	190,800
Saw-whet Owl and Goshawk	1,858	849	189,951
Potential Goshawk Habitat	2,516	1,503	188,448
Potential Blue Heron Nesting	108	34	188,414
Red Listed Site Series	9,828	1,667	186,747
Blue Listed Site Series	77,486	8,776	177,971
Riparian Buffers	205,860	44,654	133,317
Not Sufficiently Restocked	6,583	1	133,316
In Block Reductions (Monumental Cedar 13.7%, CMTs 7.7%, HTFF 5%)	32,456	7,006	126,311
Future Roads Trails and Landings	8,870	6,009	120,301

Note *: In preparation of the base case data set, the exclusions for potential goshawk habitat and potential blue heron nesting sites were not made. Therefore, **the base case timber harvest land base inadvertently included those areas and was consequently 0.85% larger that shown (or 121,329 ha) for the TSA**. This magnitude of difference is not highly consequential for timber supply given the level of uncertainties surrounding other factors; however, this difference will be highlighted to the appropriate decision makers during AAC determination processes.

TABLE 3: TFL58 TIMBER HARVESTING LAND BASE DEFINITION

Haida Gwaii Netdown	GROSS REDUCTIONS	NET REDUCTIONS	NET AFTER REDUCTIONS
Management Unit	TFL58	TFL58	TFL58
Gross Area			27,873
Lakes, Wetlands, Rivers	204	204	27,669
Non Productive	1,104	945	26,724
Non Forested	115	115	26,609
No Typing Available	813	813	25,796
No Species Info in Inventory	711	87	25,709
Conservancies	3,262	2,870	22,839
Non-forest management administration	222	175	22,664
Terrain Stability Classes 4 and 5	2,320	2,192	20,472
Economically Inoperable	59	53	20,419
Cedar Stewardship Areas	279	166	20,253
Forest Reserve Network	1,389	1,111	19,142
Wildlife Habitat Areas	0	0	19,142
Active Fluvial Units	1,775	1,070	18,073
Forested Swamps	433	245	17,828
Saw-whet Owl and Goshawk	0	0	17,828
Potential Goshawk Habitat	455	335	17,493
Potential Blue Heron Nesting	0	0	17,493
Red Listed Site Series	3	0	17,493
Blue Listed Site Series	2,000	199	17,293
Riparian Buffers	7,959	3,870	13,423
Not Sufficiently Restocked	279	0	13,423
In Block Reductions (Monumental Cedar 13.7%, CMTs 7.7%, HTFF 5%)	1,341	200	13,222
Future Roads Trails and Landings	558	380	12,843

Note *: In preparation of the base case data set, the exclusions for potential goshawk habitat and potential blue heron nesting sites were not made. Therefore, **the base case timber harvest land base inadvertently included those areas and was consequently 1.96% larger that shown (or 12,843 ha) for TFL 58**. This magnitude of difference is not highly consequential for timber supply given the level of uncertainties surrounding other factors; however, this difference will be highlighted to the appropriate decision makers during AAC determination processes.

TABLE 4: TFL60 TIMBER HARVESTING LAND BASE DEFINITION

Haida Gwaii Netdown	GROSS REDUCTIONS	NET REDUCTIONS	NET AFTER REDUCTIONS
Management Unit	TFL60	TFL60	TFL60
Gross Area			180,133
Lakes, Wetlands, Rivers	5,920	5,920	174,213
Non Productive	24,896	24,605	149,607
Non Forested	2,101	2,097	147,510
No Typing Available	1,386	993	146,517
No Species Info in Inventory	3,006	2,329	144,188
Conservancies	40,217	22,606	121,581
Non-forest management administration	9,640	7,908	113,673
Terrain Stability Classes 4 and 5	10,589	9,346	104,328
Economically Inoperable	581	267	104,061
Cedar Stewardship Areas	11,552	10,097	93,964
Forest Reserve Network	12,231	9,531	84,433
Wildlife Habitat Areas	241	0	84,433
Active Fluvial Units	12,803	3,594	80,839
Forested Swamps	206	18	80,820
Saw-whet Owl and Goshawk	1,575	701	80,120
Potential Goshawk Habitat	1,801	1,262	78,858
Potential Blue Heron Nesting	100	42	78,816
Red Listed Site Series	2,577	134	78,682
Blue Listed Site Series	17,809	5,538	73,145
Riparian Buffers	41,394	12,178	60,966
Not Sufficiently Restocked	4,961	0	60,966
In Block Reductions (Monumental Cedar 13.7%, CMTs 7.7%, HTFF 5%)	12,665	3,157	57,809
Future Roads Trails and Landings	3,345	2,234	55,574

Note *: In preparation of the base case data set, the exclusions for potential goshawk habitat and potential blue heron nesting sites were not made. Therefore, **the base case timber harvest land base inadvertently included those areas and was consequently 1.64% larger that shown (or 56,484 ha) for TFL 60**. This magnitude of difference is not highly consequential for timber supply given the level of uncertainties surrounding other factors; however, this difference will be highlighted to the appropriate decision makers during AAC determination processes.

Waterbodies and non-productive forest

Non-forest and non-productive forest area was derived from Terrestrial Resource Inventory Mapping (TRIM), and was excluded from the THLB. Tables 5 and 6 outline exclusions by land class.

Normally the inventory file for a management unit is the source of information on non-forest and non-productive land. However there were 4 separate inventory files for Haida Gwaii each containing different formats of such information. A resultant file that amalgamated inventories for all of Haida Gwaii was prepared for use in timber supply analyses to support the SLUA and the LUOO. That file contained the best available information on non-forest and non-productive land. It was sourced from Cortex consultants. Areas in Table 6 are from that file.

TABLE 5: TRIM WATERBODIES (LAKES, RIVERS AND WETLANDS)

	TFL58	TFL60	TSA25	TOTAL
Lake	128	4,547	8,804	13,478
River	8	231	448	688
Wetland	68	1,141	48,612	49,821
Total	204	5,920	57,863	63,987

TABLE 6: FOREST INVENTORY NON-FOREST AREAS

	TFL58	TFL60	TSA25	TOTAL
Alpine	495	248	29,300	30,043
Alpine Forest	0	0	3,343	3,343
Clay Bank	37	0	41	77
Clearing	0	0	525	525
Gravel Bar	0	0	114	114
Gravel Pit	0	0	4	4
Lake	6	34	72	111
Meadow	0	0	110	110
Non-Productive	177	927	9,414	10,518
Non-Productive Brush	5	21,918	13,076	34,999
Non-Productive Burn	0	0	25	25
River	27	0	215	242
Rock	10	51	3,789	3,850
Salt Water	18	56	672	746
Sand	0	0	358	358
Swamp	330	1,662	41,323	43,316
Tidal Flat	0	0	730	730
Urban	0	0	1,356	1,357
TOTAL	1,104	24,896	104,467	130,467

Non-forest, no typing, no species information

Non-forested land was identified using the NF_DESC variable from the land use planning file. Areas labelled as NC and NTA were excluded from the THLB.

The "no typing available" areas in Tables 1 through 4 were identified using a new NTA variable. The new NTA signifies either that there is no coverage from the consolidated inventory file, or that the consolidated inventory file does not contain inventory information such as species, age, height, or site index. RESULTS data was used to override the new NTA label where it was available.

The no species information category includes areas where there is inventory layer coverage, but no species information in the polygon, and where there is no RESULTS data to override the information gap.

The following table indicates the total areas in hectares of each category that were excluded from the timber harvesting land base.

TABLE 7: NON-FOREST, NO TYPING AVAILABLE, NO SPECIES INFORMATION (TOTAL AREA IN HA)

	TFL 58	TFL 60	TSA 25	TOTAL
Non-forest	115	2,101	2,707	4,923
No typing available	813	1,386	22,367	24,566
No species information	711	3,006	25,702	29,419

Unstable terrain

Unstable terrain, which is subject to mass wasting disturbance such as landslides, may not be suitable for timber harvesting.

In previous timber suply reviews (TSRs), different approaches were used in the various management units for defining unstable terrain, with different percentages of the terrain classes (IV or V) being excluded from the THLB. The reasons for these differences are not known. Therefore, for this analysis a consistent approach based on actual practice was developed for application to all manageement units.

An empirical approach was used to determine how much harvesting has occurred in terrain class IV and V based on data from an area of 11,679 hectares, harvested between 2000 and 2010. Data was sourced from the *electronic commerce appraisal system (ECAS).*

Areas of concern are comprised of terrain class IV and V, within the preliminary THLB[1].

The assumption proposed for this analysis is that if a terrain class contributed to harvesting in proportion to its contribution to the THLB (prior to exclusion of any unstable terrain), then no area should be removed from the THLB. Therefore, to define an appropriate exclusion, a 'preference'

[1] Preliminary THLB includes reductions due to EBM constraints, but does not exclude unstable terrain or economically inoperable lands.

ratio of the percent contribution of harvest within each terrain class, to the percent contribution of the class to a preliminary THLB was calculated. The ratio was calculated as follows:

$$1 - \frac{(\sum x_0) \div (\sum y)}{(\sum a_0) \div (\sum b)}$$

Where *x* is the area of harvested blocks in a given terrain class (IV or V, represented by *0)*, y is the total area of the harvested blocks, *a* is the area of each terrain class, and *b* is the total area of preliminary THLB.

The result of this analysis showed that 87% of all harvested area was outside of unstable terrain, and 8% and 5% of the area harvested was within class IV and V terrain, respectively. Using the 'preference' ratio described above, this translates into 23% of terrain class IV being considered inaccessible and 49% of class V considered inaccessible. For modeling purposes this was applied as a 25% exclusion for class IV terrain and a 50% exclusion for class V terrain.

TABLE 8: INPUTS TO THE UNSTABLE TERRAIN REDUCTIONS

(1) Terrain Stability Class	(2) Approx. THLB >100 yrs prior to terrain exclusion (ha)	(3) Percentage THLB >100 yrs	(4) Harvested area from ECAS* (ha)	(5) Percentage contrib. to harvest	Exclusion percentage 1 - Column (5)/Column (3)
0	68 661	80.6%	10 195	873%	-8%
4	9 045	10.6%	957	8.2%	23%
5	7 466	8.8%	527	4.5%	49%
Total	85 172	100%	11 679	100%	

* ECAS – Electronic Commerce Appraisal System

It should be noted that preliminary THLB used for this assessment included only landscape units that contains THLB within terrain stability classes 4 and 5.

Only forest older than 100 years was included in defining the exclusion factors for unstable terrain for two reasons. First, the harvests recorded in ECAS are from older stands. Second, it is assumes that forest management on terrain class IV or V terrain would only occur in old forests due to the high costs associated with this harvest regime and the lower values associated with managed stands. Therefore, the net down was developed using information only on stands over 100 years old, and was applied only to such stands. Younger stands (<100 years old) were not part of this unstable terrain analysis, and were not netted out on the basis of terrain class.

A potential concern with the approach used here is that simply because a type of area was harvested in the past does not mean that such practice is consistent with sound forest management. While local Forest and Range Evaluation Program data does not provide information on harvests on potentially unstable terrain, Haida Gwaii district staff indicate that harvesting since 2006 in such areas demonstrates sound forest management[2].

Economically inoperable forest

Economically inoperable areas are areas that are not available for timber harvesting because of physical inaccessibility or stand attributes from the inventory that make harvesting uneconomic.

A variety of approaches and information sources have been used in past TSRs on Haida Gwaii to describe forest types and areas that are believed to be economically infeasible to harvest. In general the approaches employed operability mapping in conjunction with information on inventory types (tree species groupings) and timber volume. Minimum volume thresholds were developed based on these information sources, but the methods used for deriving the specific dividing lines between operable and inoperable in the various management units were not documented in the previous TSR analysis reports. Operability mapping was available for all tenures, based upon photo or air-call interpretation, GIS models, or field validation of potential harvest systems (conventional vs. non-conventional) or access classes. However, the standards for the creation of these data layers vary across tenures and the rationale for these standards are unique to each management regime and subject to considerable change over time and between tenures. The use of operability mapping, in conjunction with inventory types and volume thresholds was the basis for defining economic operability across different management units during the most recent TSRs for each management unit.

One type of economic operability analysis involves calculating a Mean Value Index (MVI) by subtracting local development, harvesting, and transportation costs from price estimates by species and grade. While some of these types of analyses have been done on Haida Gwaii[3], the results often do not represent a definitive indication of operability. To provide an accurate assessment of economic operability an MVI requires accurate information on costs and values. In reality such information is rarely available. Coast Appraisal Manual costs are based on averages that do not necessarily reflect local conditions. In addition, the ability for licensees to combine blocks in innumerable ways when determining what is economically operable for them creates significant uncertainty about what costs and values licensees actually experience when harvesting on a stand by stand basis. Comparison of appraisal manual costs with actual costs from ECAS for other areas of BC shows that there is not a consistent relationship between them. One possible reason for this lack of relationship is the practice of block blending whereby forest industry operators combine several harvest blocks into one reporting and operating unit. The costs associated with the

[2] Sean Muise, Haida Gwaii Natural Resource District Stewardship forester, Personal communication.

[3] Timber Opportunity Analysis. 2007. Timber Harvesting Opportunities Arising from the Implementation of the Proposed Land Use Zones and EBM Provisions- Haida Gwaii Strategic Land Use Agreement of May 29, 2007. Report to the Council of the Haida Nation and the Integrated Land Management Branch.

Howard, A. 2007. Operational Feasibility of Forest Management Plans Created with Spatial Models. Cortex consultants final report to Husby Forest Product, Ltd., Western Forest Products Inc., Teal Jones Group.

Wang, E, 2002. Haida Gwaii/ QCI Land Use Plan Woodshed Analysis. Final Report to the Ministry of Sustainable Resource Management, Nanaimo, B.C.

aggregate area may not reflect appraisal manual figures. On the value side, it is very difficult to ascertain the revenues that a licensee may be able to receive for the timber in a block. Historic averages, likely to be the best available information on prices, may not reflect those experienced in a specific area. Finally, MVI analyses require significant time and resources to undertake, while the timeline for this TSR is limited. For all of these reasons, the JTWG decided not to undertake an MVI-style of operability analysis.

Given the variety of operability approaches used in previous analyses, and the lack of understanding of the specific rationale used in the previous work, it was necessary for the joint Haida-BC technical working group (JTWG) to develop and apply a new, consistent economic operability approach.

Empirical economic operability assessment approach

An empirical approach was used by the JTWG for defining un-economic stands. The JTWG wanted to find logical parameters that could be correlated with operability. These parameters represent limitations of physical operability and timber merchantability and were developed using a retrospective approach in which 10 years of harvest history and information pertaining to their inventory types and slope were correlated. The objective was to define the minimum volume thresholds for various stand types and slope classes. Another common parameter affecting economic operability in some forest districts in BC is hauling distance. However, Haida Gwaii District staff indicated that haul distance is not a significant factor for Haida Gwaii.

Inventory type and minimum volume thresholds were used as a surrogate for the merchantability of a stand (value), while slope was used as a surrogate for the relative accessibility of harvesting (cost).

Inventory types were analyzed using forest cover inventory over all management units, and 14 types were identified as encapsulating 83% of the forest area of Haida Gwaii and 98% of the volume.

Inventory types identified for economic operability model:

CWHW	YCHW
HWSS	SSCW
HWCW	HWYC
CWYC	PLCW
SSHW	CWSS
CWPL	SS
YCCW	HWPL

CW – western redcedar
HW – western hemlock
PL – lodgelpole pine
SS – sitka spruce
YC – yellow cedar (cypress)

Slope classes were derived from the *Terrain Classification System of BC*[4] and were defined as:

Slopes between 0-26 %
Slopes between 26-49%
Slopes between 50-70%, and;
Slopes greater than 70%

Using a filter of stands greater than 100 years and greater than 50m^3/hectare, the timber harvesting land base was divided by inventory type and slope class. Using the same filter for THLB, harvested cutblock data from the Electronic Commerce Appraisal System (ECAS) was similarly divided by inventory type and slope class. Cutblock data represented harvesting between 2000 and 2010, and consisted of 9,884 hectares. ECAS data was used as it represents harvested blocks, as opposed to proposed (and potentially unviable) blocks. Minimum, maximum and average m^3/ha were generated by inventory group and slope class (see table 9). The 99th percentile of m^3/hectare was used to define the minimum volume thresholds. While the ECAS cutblock boundaries used to define the trends for areas harvested, volume data was sourced from the forest cover inventory.

Note that volumes for some inventory types/slope classes seem very low (e.g. less than 100 m^3/ha; see Figure 3), at least lower than what would be expected to be economic. This led to a comparison of ECAS cruise-based volumes with forest inventory volumes on a management unit basis in order to legitimatize the minimum volume thresholds (Figure 2). *Variable Density Yield Prediction* software (VDYP7) was used to generate volumes across all management units using inputs from the forest cover inventory[5]. The results from this analysis show that, while there is little to no correlation between the actual inventory derived volumes and the cruise based volumes, the low inventory volumes (<200m^3/ha) do correspond to much higher cruise based volumes. For example, in Figure 2, a VDYP7 volume (based on forest inventory) may show a low 200 m^3/ha stand, but in reality that typically corresponds with a >400 m^3/ha stand from the cruise volumes. This validates the model's minimum volume threshold as representing marginally economic stands.

Minimum volume thresholds were also compared by species and slope class and the variables reasonably fit ecological and harvest operational patterns on Haida Gwaii (Figure 3). For example, the trend shows that with greater drainage (higher slope class), the stand volumes increase.

Inventory types and slope classes that accounted for less than 1% of the THLB were not included in the analysis. Inventory types below the minimum volume threshold were identified and removed from the Timber Harvesting Land Base. This method for classifying, and subsequently mapping economic operability resulted in a gross reduction of 85,644 hectares.

---

[4] Howes, D.E. E.Kenk. 1997. Terrain Classification System For British Columbia (version 2). Resource Inventory Branch, Ministry of Environment, Lands and Parks.

[5] VDYP7 volumes were used instead of inventory volumes due to either gaps or inconsistencies in fc inventory volume data across management units.

TABLE 9. MINIMUM HARVESTED VOLUME BY INVENTORY TYPE AND SLOPE CLASS

Species 1, 2	99th percentile of **m^3/ha** slope class 2	99th percentile of **m^3/ha** slope class 3	99th percentile of **m^3/ha** slope class 4	99th percentile of **m^3/ha** slope class 5
CWCY	90	98	102	175
CWHW	70	120	131	131
CWPL	60			
CWSS	180	184	511	
CYCW	101	110	120	121
CYHW	100	100	107	200
HWCW	100	223	209	261
HWCY	100	70	188	111
HWSS	200	340	370	370
PLCW	70			
SSCW	328			
SSHW	203	300	320	469

For the HWCY inventory type, it was assumed that the decline in minimum volume harvested from slope class 4 to slope class 5 was an inventory anomaly, since it is logical to expect that harvesting on steeped slopes would be more expensive, and hence that the volume threshold for economic harvesting on steeper slopes would be higher than for less steep slopes. For the purpose of defining the economic operability threshold for this stand type, it was assumed that the minimum volume harvested from slope class 5 was equal to the minimum volume harvested from slope class 4.

This information in Table 9 is displayed graphically in Figure 3, below. For some forest classes (i.e., CwPl, PlCw, and SsCw), the data indicated that volume was harvested only in slope class 2, therefore no line appears in Figure 3 for those forest classes.

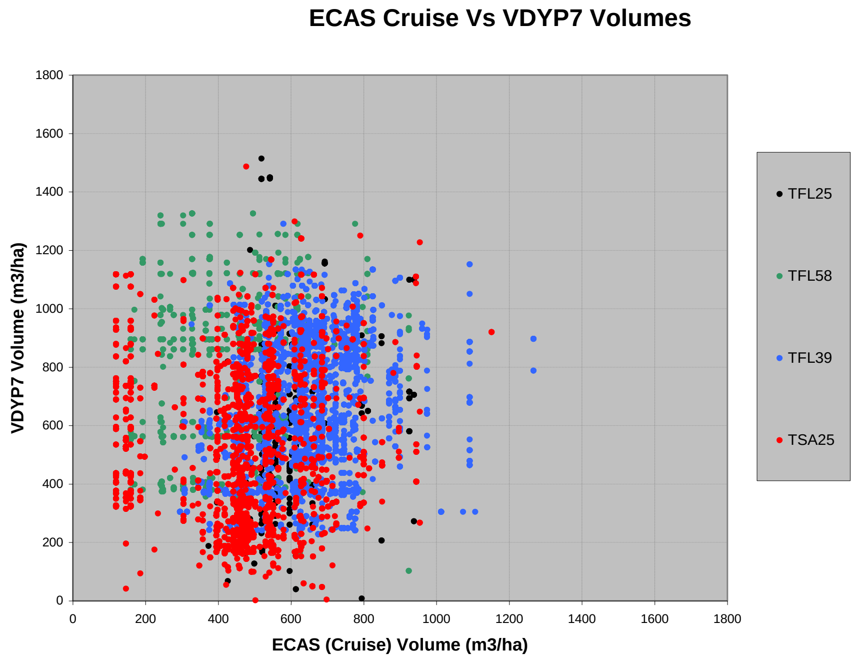


FIGURE 2 CRUISE VOLUME COMPARISON WITH INVENTORY DERIVED VOLUMES

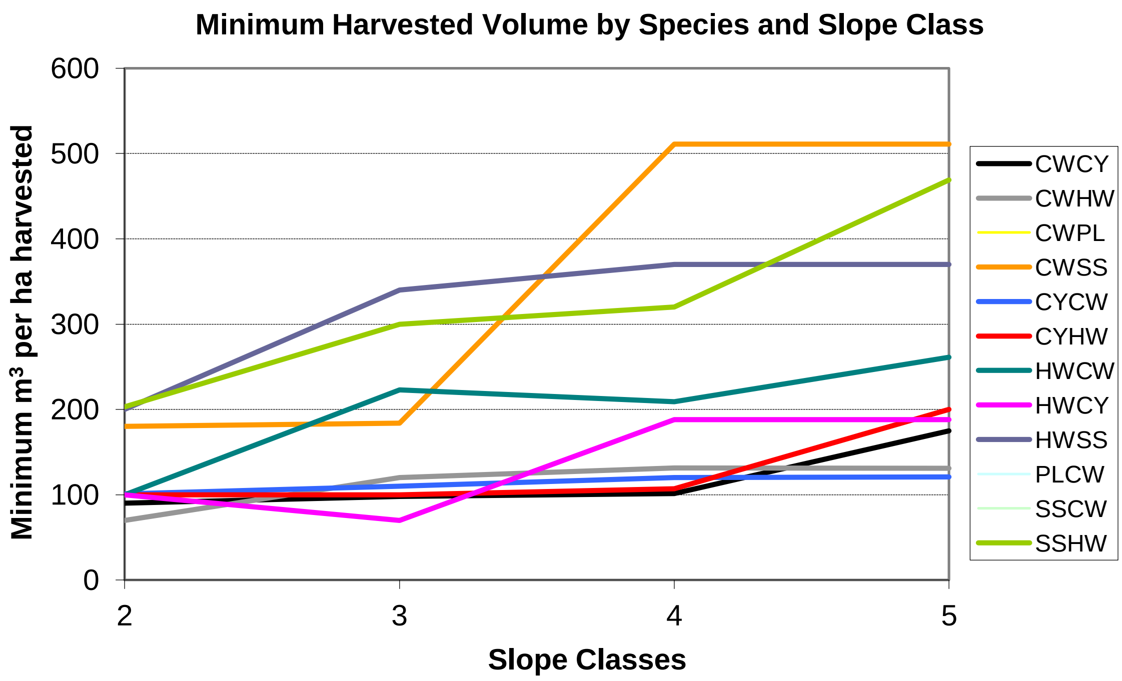


FIGURE 3 MINIMUM VOLUME THRESHOLD IN RELATION TO INVENTORY TYPE AND SLOPE CLASS

Table 10 includes details on the minimum, maximum, average, and 99th percentile volumes harvested in each slope class-inventory type grouping. The cut-off for economic operability was set at the 99th percentile, meaning that 99 percent of the volume harvested was taken from stands with that volume or higher. The 99th percentile volumes are summarized in Table 9 and Figure 3, above.

TABLE 10: MINIMUM VOLUME THRESHOLDS FOR ECONOMIC OPERABILITY

Slope Class	Sp 1	Sp 2	Min m^3/ha	Max m^3/ha	Avg m^3/ha	99th percentile of m^3/ha
2	CW	CY	83.3	959.5	301.8	90.0
2	CW	HW	51.9	1,330.4	383.8	70.0
2	CW	PL	52.0	746.8	338.1	60.0
2	CW	SS	175.4	1,114.5	584.1	180.0
2	CY	CW	101.2	689.1	405.5	101.0
2	CY	HW	191.0	828.7	450.0	190.0
2	HW	CW	62.6	1,308.6	581.4	100.0
2	HW	CY	73.4	1,072.7	673.9	200.0
2	HW	SS	202.3	1,525.4	737.6	200.0
2	PL	CW	50.2	748.5	247.1	70.0
2	SS	CW	329.0	1,886.2	636.0	328.0
2	SS	HW	203.9	1,399.5	778.3	203.0
3	CW	CY	98.5	959.5	283.4	98.0
3	CW	HW	96.2	1,231.6	510.6	120.0
3	CW	SS	184.4	894.4	607.1	184.0
3	CY	CW	102.1	913.5	420.7	110.0
3	CY	HW	94.1	889.2	477.8	100.0
3	HW	CW	185.9	1,292.8	628.9	223.0
3	HW	CY	73.4	1,041.5	633.8	70.0
3	HW	SS	202.3	1,216.5	721.8	340.0
3	SS	HW	203.9	1,308.1	818.0	300.0
4	CW	CY	83.3	780.2	338.5	101.5
4	CW	HW	97.9	1,231.6	537.2	131.4
4	CW	SS	253.7	645.0	575.3	511.0
4	CY	CW	102.1	683.6	430.3	120.1
4	CY	HW	94.1	648.7	432.2	107.0
4	HW	CW	194.5	1,195.8	609.3	209.0

Slope Class	Sp 1	Sp 2	Min m^3/ha	Max m^3/ha	Avg m^3/ha	99th percentile of m^3/ha
4	HW	CY	73.4	1,041.5	622.0	188.0
4	HW	SS	298.4	1,403.3	766.8	370.0
4	SS	HW	271.2	1,221.1	792.6	320.0
5	CW	CY	83.3	581.3	320.8	175.0
5	CW	HW	121.5	1,051.6	475.8	131.0
5	CY	CW	113.7	668.0	372.1	121.0
5	CY	HW	200.1	855.2	415.3	200.1
5	HW	CW	82.2	934.2	620.8	261.0
5	HW	CY	77.2	1,041.5	514.9	111.0
5	HW	SS	304.2	1,403.3	746.1	304.2
5	SS	HW	469.1	1,169.6	791.1	469.0

Low productivity sites

In many TSRs, areas defined as low productivity lands are excluded from the THLB. These are normally second-growth stands which are not anticipated to achieve merchantable volume within a reasonable amount of time. Low volume mature or old-growth stands are excluded as economically inoperable (see above)

For this analysis, no exclusion was done for low productivity stands. Rather, minimum harvestable ages were developed based on site productivity estimates, and for lower productivity sites those ages may be very long. The outcome of very long harvest ages is that the stands will be projected to be harvested very infrequently and may not be harvested within the horizon for the timber supply analysis. This would amount to an effective exclusion of sites with very low productivity.

Non-merchantable forest types

In many TSRs, forest stands that are either believed to be uneconomic to harvest, or are not utilized as part of current management (frequently deciduous stands) are excluded as “non-merchantable forest types.” For this analysis, uneconomic stands are addressed under “Economically inoperable.”

Administrative classes not contributing to forest management objectives

The following table shows areas in administrative classifications that do not contribute to forest management objectives. They were excluded from the timber harvesting land base.

TABLE 11: ADMINISTRATIVE OR OWNERSHIP CLASSES THAT DO NOT CONTRIBUTE TO FOREST MANAGEMENT OBJECTIVES

Ownership Code	Description	TFL58	TFL60	TSA25	TOTAL
40N	Private - Crown Grant	160	9,618	9,920	19,698
50N	Federal Reserve	5	0	16,817	16,835
51N	National Park	0	0	129,898	129,898
52N	Indian Reserve	16	1	1,307	1,324
53N	Military Reserve	0	0	917	917
60N	Crown Ecological Reserve	0	0	1,465	1,465
61N	Crown UREP	0	0	120	120
63N	Crown Prov Park Class A	35	0	73,980	74,015
67N	Crown Prov Park equiv or Reserve	1	7	360	368
69N	Crown Misc Reserve	5	14	1,228	1,247
99N	Crown Misc. Lease	0	0	2	2
TOTAL		222	9,640	236,014	245,876

There are 73 active Timber Licenses making up approximately 63,530 hectares on Haida Gwaii. While Timber Licenses have been included in harvest flows and forecasts, there is uncertainty as to the particular reversion schedules of each; however this uncertainty does not affect timber supply.

Roads, trails and landings

Estimates of the loss of productive forest land due to existing and future roads, trails and landings (RTL) were derived from an analysis of 975 blocks with roads from the RESULTS database. The blocks were from a period from 1985 and 2009. The total roaded (NP) area of each block was divided by the total area of each block to determine the net down, or exclusion, factor. The total RTL resulted in an average netdown of 5.75%.

No land was removed to account for future roads, trails and landings. The impacts on the THLB were modeled as a reduction to growth and yield tables for regenerated stands. The impact on the yield tables is equivalent to the land being withdrawn from further timber supply contribution at the time of first harvest.

4.0 Management units and analysis units

This Timber Supply Review is treating the operating forestry landbase as one management unit for the purposes of section 5 of the *Haida Gwaii Reconciliation Act*. While this aggregated sum of all management units is a primary focus, analysis has been completed for 4 management units, 3 of which inform the final recommended timber supply forecasts for use in the provincial Chief Forester AAC determinations for each TSA and TFL.

TABLE 12: MANAGEMENT UNITS IN HAIDA GWAII

Management unit	Current AAC	Comments
TSA 25	869,748 m³/year	Informs the HGMC Annual Allowable Cut (AAC) determination and Chief Forester determination
TFL 60	802,868 m³/year	Informs the HGMC Annual Allowable Cut (AAC) determination and Chief Forester determination
TFL 58	100,000 m³/year	Informs the HGMC Annual Allowable Cut (AAC) determination and Chief Forester determination
Woodlot Licenses (WLs)	9,293 m³/year	There are currently 4 WLs (Younger, Lavoie, Skidegate Band, Old Masset Band). These areas have been excluded from the timber harvesting land base for this analysis. Information on WLs AACs will be presented to the HGMC for consideration.
Haida Forestry License to Cut (FLTC)	120,000 m³/year (part of the TSA AAC)	The FLTC may be replaced by another tenure form. The area is currently part of TSA 25. The boundary of the area is considered subject to the FLTC was included in the analysis data set to allow for understanding of its contribution to the TSA timber supply.
Private Lands	Not applicable	Not part of the AAC determination. Primarily Island Timberlands holdings. Information on private land harvests will be provided to the HGMC.

The map on the following page shows the different types of management units on Haida Gwaii.

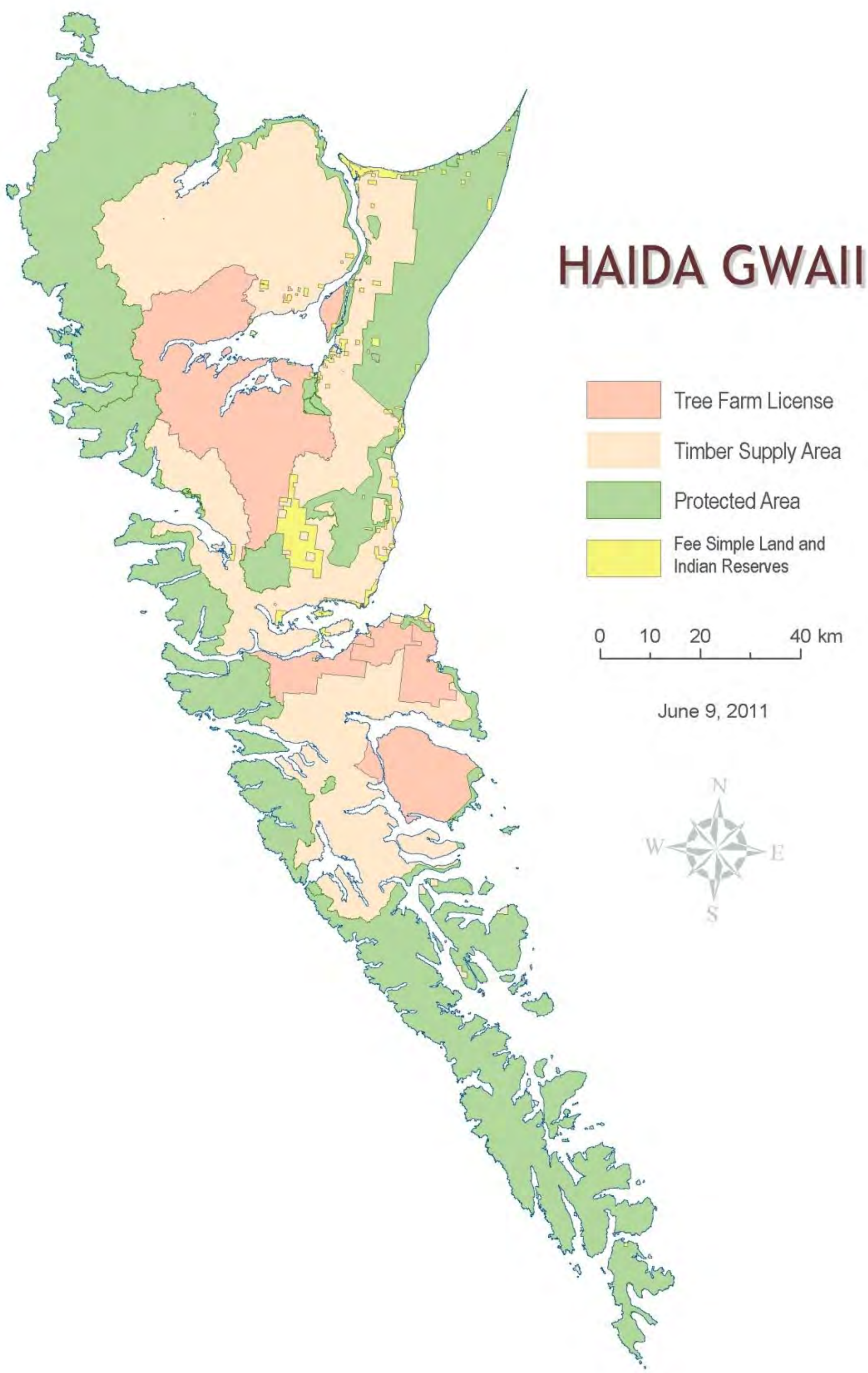


FIGURE 4: MAP OF MANAGEMENT UNIT TYPES ON HAIDA GWAII

Analysis units

Stands are often combined into analysis units to reduce the amount of information used in timber supply modeling. Usually analysis units are comprised of combinations of stands with similar tree species, timber growing capability and sometimes silvicultural management regimes.

The Forest Service Spatial Analysis Model (FSSAM) has the capacity to process yield information for individual stands. For this analysis, each existing stand older than 30 years of age was initially assigned its own individual VDYP yield curve. Approximately 47,000 existing natural stands were tracked in the model.

Growth and yield in managed stands, that is, post-harvest stands that have been subject to management of stocking densities and sometimes brushing, was modeled using TIPSY (Table Interpolation Program for Stand Yields). Managed stands were aggregated by BecLabel, Site Series and the first three species labels. There were 725 existing managed stand groups, and 1465 future managed stand groups for a total of 2,190 existing managed stand polygons.

Where available information from RESULTS was used to create inputs for MSYTs (Managed Stand Yield Tables). About 20,000 ha of cutblocks less than 30 years old were not included in RESULTS. These areas were assigned to future MSYTs, and information on attributes necessary to generate MSYTs was taken from the inventory.

Table 13 shows area in the current THLB by leading species and site index range.

TABLE 13. DISTRIBUTION OF ANALYSIS UNITS (AGGREGATED FOR REPORTING PURPOSES) FOR EXISITNG AND FUTURE MANAGED STANDS.

	Current THLB (ha)						
SI for Sp1 (m@50 yrs)	Hemlock	Cedar	Spruce	Yellow cedar	Pine	Alder	TOTAL
0	7	0	29	0	0	0	35
1 - 5	259	93	44	30	0	0	426
6 - 10	5,145	32,339	531	1,733	195	13	39,957
11 - 15	13,705	30,615	1,794	3,749	991	133	50,987
16 - 20	13,627	11,095	1,673	1,572	1,727	240	29,934
21 - 25	24,067	2,743	4,930	83	437	633	32,894
26 - 30	21,719	38	11,955	0	82	524	34,318
31 - 40	3,075	19	5,152	0	0	544	8,790
TOTAL	81,605	76,942	26,107	7,168	3,432	2,088	197,342

5.0 Growth and Yield

Site Index

Site index (SI) is a measure of site productivity. Indices are reported as the average height, in metres, that the tallest trees in a stand are expected to achieve at 50 years of age.

Several site productivity studies on Haida Gwaii have demonstrated that inventory information from old-growth forest stands under-estimates the actual productivity of forest sites. This work includes studies on stump site index[6], and on biophysical-based site index adjustment (SIA)[7]. In addition, a 1992 and 1998 Forest Inventory Audit[8] provided updated information on height and age that could be used as inputs for SI definition. The Haida Gwaii studies confirm results from elsewhere in British Columbia[9]. Given this research, efforts have been made by the joint Haida-BC technical working group (JTWG) to compile the best available site productivity information for Haida Gwaii.

In this section the various sources of site productivity information are described, some challenges associated with determining which information sources represent the best available information are discussed, and the site productivity schema for the base case and sensitivity analyses are outlined.

---

[6] Hardy, K. 2005. Remeasurement of 2nd growth permanent sample plots on Moresby Island. Project Report SFM08-04, South Moresby Forest Replacement Account.

Hardy, K. 2006. Remeasurement of 2nd growth permanent sample plots on Moresby Island. Project Report SFM15-05, South Moresby Forest Replacement Account

Hardy, K. 2007. Queen Charlotte Islands stump-site index study. Nanaimo, BC: Coast Forest Region, Ministry of Forests and Range

[7] Timberline Forest Inventory Consultants. 2002. Queen Charlotte Timber Supply Area Second Growth Volumes Study, Results Update. Report prepared for Husby Forest Products, Ltd.

Timberline Natural Resource Group. 2010. Site index adjustment of the Haida Gwaii Timber Supply Area, Draft Report. Project no. BC0107890. Report prepared for British Columbia Ministry of Forests and Range, Forest Analysis and Inventory Branch.

[8] B.C.Ministry of Forests. 2000. Queen Charlotte Timber Supply Area Analysis Report. Appendix A Description of Data inputs and Assumptions for the Timber Supply Analysis: *p.110.*

[9] Mah, S. and Nigh, G.D. 2003. SIBEC site index estimates in support of forest management in British Columbia. Tech. Rep. 004. Victoria: B.C. Ministry of Forests, Research Branch. http://www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr004.pdf

Nigh, G.D. 1998. Site index adjustments for old-growth stands based on veteran trees. Working Paper 36/1998. Victoria: B.C. Ministry of Forests, Research Branch. http://www.for.gov.bc.ca/hfd/pubs/docs/wp/wp36.htm

Nussbaum, A.F. 1998. Site index adjustments for old-growth stands based on paired plots. Working Paper 37/1998. Victoria: B.C. Ministry of Forests, Research Branch. http://www.for.gov.bc.ca/hfd/pubs/docs/wp/wp37.htm

Site productivity sources and studies

Stump site index

The stump SI work of Hardy (2005, 2006, 2007)[10]provided statistically valid site index adjustments for western hemlock and Sitka spruce stands. This study was based on "rebuilding" old-growth trees from the stumps of dominant or co-dominant western hemlock, Sitka spruce and western redcedar on TFL 39, Block 6 (now TFL 60) using taper equations and existing cruise data. Findings were considered to be applicable to the entire operating landbase (TFLs and TSA). A growth-intercept method was used to determine logged and regenerated (LAR) site index for spruce and hemlock second growth stands. A statistically significant regression for cedar stands could not be developed based on the data collected in the stump SI study.

Stump SI estimates[11] for stands over 140 years of age throughout Haida Gwaii for Sitka Spruce and/or Western Hemlock leading logged and recovered (LAR) stands, are outlined in the following table. Stump site index studies have documented localized site index adjustments for LAR sites.

TABLE 14. REGRESSION COEFFICIENTS (A) AND INTERCEPTS (B) FOR DETERMINING LAR SITE INDEX FROM OG SITE INDEX, USING THE SIMPLE LINEAR REGRESSION EQUATION: LAR SI = A +B(OG SI)

OG to LAR species transitions	n[1]	SE_E	R^2	Para-meter	Esti-mate	Std. Error	Signif-icant @ α=0.05	**MAX** LAR SI[t]
Hemlock OG sites								
Hemlock OG to hemlock LAR	29	3.403	0.4467	a	10.182	4.3310	YES	**40**
				b	1.2520	0.2681		
Hemlock OG to Sitka spruce LAR	27	4.043	0.3689	a	11.293	5.2120	YES	**41**
				b	1.2390	0.3240		
Sitka spruce OG sites								
Sitka spruce OG to Sitka spruce LAR	16	4.953	0.2587	a	22.517	9.0440	YES	**37**
				b	0.4315	0.2830		

[1] n = number of samples

[t]MAX LAR SI is the maximum value that each LAR species should be adjusted to in order to fall within the known range of OG site index observed in the Queen Charlotte TSA.

The scope of application of SIs derived based on the stump study in the timber supply analysis is described below under "Site productivity schema for timber supply analysis."

---

[10] Hardy, K. 2007. Queen Charlotte Islands Stump-Site Index Study. Ministry of Forests and Range, Coast Forest Region. Nanaimo, BC.

[11] Hardy, K. 2007. Queen Charlotte Islands stump-site index study. Nanaimo, BC: Coast Forest Region, Ministry of Forests and Range

RESULTS

The RESULTS data base contains SI estimates for some stands. These estimates are based on growth intercept or SIBEC[12] applied based on site specific assessment of site series. Given the site specific nature of these SI assignments, the RESULTS data base was believed to be a good source of information for younger stands.

Site index estimates were used from RESULTS where available. RESULTS houses silviculture information, and include site index estimates. These estimates are derived from a variety of sources, and are considered to be more reliable than inventory site index.

TABLE 15. REFERENCE OF SOURCES FOR SITE INDEX USED IN THE RESULTS DATABASE.

Code	Code Description (source of site index)
A	Adjacent stand
C	Site index curve
E	Biogeoclimatic Ecosystem Classification
H	Stand before harvest
I	Growth intercept
M	G, M, P, L site class conversion
O	Provincial SIBEC rollover, Nov 1998
S	Assigned by District Silviculture Section

SIBEC and ecosystem mapping

Site Index estimates by Site Series (SIBEC) reflects the relationship between tree growth and site factors. Site factors including climate (light and temperature) and soil moisture, nutrients and aeration all influence the productivity of a site. The SIBEC program was established in 1994 as a result of a need to determine more reliable site index estimates for old forests. The SIBEC model uses model-based inference to relate site index to BEC site series for coniferous tree species in BC[13]. Second approximations of SI estimates are reported by biogeoclimatic variant and species (see Appendix 1). Site index estimates are then related to ecosystem mapping inventories that have been compiled during the Land Use Planning Process. Ecosystem mapping on Haida Gwaii is made up of several tenure specific projects.

Protocols for using ecosystem mapping in timber supply modeling were developed in 2003 by the Ministry of Forests Forest Science Program[14]. The protocols outline minimum accuracy assessment results and standards for using ecosystem mapping in TSR base cases.

[12] Site Index based on the Biogeoclimatci Ecosystem Classification system (SIBEC).

[13] Mah, S. and G.D. Nigh. 2003. SIBEC site index estimates in support of forest management in British Columbia. Res. Br., B.C. Min. For., Victoria, B.C. Tech. Rep. 004.

[14] Meidinger, D. 2003. Protocols for Accuracy Assessment of Ecosystem Maps. Ministry of Forests Forest Science Program. Victoria, B.C.

The SIBEC framework provides a reliable source of SI estimates, but requires ecosystem mapping of site series as a basis for application.

The sources of ecosystem mapping on Haida Gwaii are:

> TFL 60 (formerly TFL 39) Terrestrial Ecosystem Mapping Project –TEM to RIC Standards (1998). Level 4 Sampling between 1995 and 1999. Approximately 270,500 ha. Q/A by B.Beese and D.Meidinger (exceeds 65% accuracy) and makes up approximately 42% of the operating area of Haida Gwaii.
>
> TSA 25 Terrestrial Ecosystem Mapping Project – TEM to RIC Standards (1998) Level 5 Sampling between 2004 and 2007. Approximately 437,200 ha. Q/A by Timberline Natural Resource Group,2008[15] (dominant entity correct with and without alternate calls= 45%/59% respectively). Makes up approximately 43% of the operating area of Haida Gwaii.
>
> TFL 58 (formerly TFL 2 and 47) – Ecosystem Mapping by Timberwest (TFL now owned by J.S. Jones) approximately 27, 300 ha. Mapping occurred prior to RIC standards, however done by Terry Lewis. Q/A not available. Makes up approximately 5% of the operating area of Haida Gwaii.
>
> TSA (formerly TFL 25) – Ecosystem mapping by Western Forest Products (mapped by Terry Lewis), completed in 1982 prior to RIC Standards (attribute revision in 2003). Approximately 52, 900 ha. Q/A not available. Makes up approximately 10% of the operating area of Haida Gwaii.

There are uncertainties about ecosystem mapping on Haida Gwaii, particularly in the TSA. The JTWG, working in conjunction with the ecologists from the Ministry of Forests, Lands and Natural Resource Operations undertook a project to adjust the TSA TEM inventory with the goal of adjusting some systematic mapping errors and increase the inventories accuracy for use in the TSR. Analyses of the mapping errors suggest that the inventory slightly under estimates site productivity[16]. Ecosystem mapping on Haida Gwaii that has not been independently assessed for accuracy (15% of the mapping) is being used on the premise that it provides superior site productivity information than using old growth site index derived from inventory attributes. Alternate site productivity information for TFLs (derived from forest inventory attributes) have likewise not been independently assessed for accuracy.

TEM (Terrestrial Ecosystem Mapping) calibration study for TSA

The JTWG completed work to explore adjustments that would rectify some of the mapping errors identified in the TSA and therefore result in a map that provides a reasonable basis for applying SIBEC to the TSA. Independent accuracy assessment data was used to analyze error trends and to

[15] Timberline Natural Resource Group, 2008. Terrestrial Ecosystem Mapping (TEM) within the Queen Charlotte Timber Supply Area. Final Accuracy Assessment. Prepared for Husby Forest Products.
[16] For CWHwh1, preliminary analysis suggests an -8% under-representation in site index.

develop an adjustment strategy[17]. The error trends were based on the site series proportions of the accuracy assessment plots sampled in the field. Assuming that the unbiased design of the accuracy assessment data represents the site series proportions for the entire TSA, then error trends for the mapped TEM for the TSA showed that:

- **CWHwh1**: The TEM has over-mapped site series 01 but under-mapped site series 04 and 10. The TEM has also over-mapped site series 05 and 06;
- **CWHwh2**: The TEM has over-mapped site series 01 and 03 but under-mapped 02 and 05;
- **CWHvh2**: The TEM has over-mapped site series 01 and 04, but under-mapped site series 06, 07, and 13.

Based on this analysis an adjustment strategy was used, which included a biophysical model approach and expert opinion[18] to mainly adjust the second and third deciles of the mapped TEM (no linework was adjusted).

The average site indexes before and after the TEM adjustments are shown in the following table:

TABLE 16: AVERAGE SITE INDEX BEFORE AND AFTER THE TEM ADJUSTMENT

Assessment Area	Area (hectares)	Adjusted Weighted Average SI TEM/SIBEC (m @ 50 yrs)	Adjusted Weighted Average SI Based on TEM Calibration Study (m @ 50 yrs)	Change (m @ 50 yrs)
FMLB[1] w SI based on TEM calibration study	158,254	18.91	19.61	0.7
THLB w SI based on TEM calibration study	82,456	18.01	18.80	0.8
THLB w/o LAR & w/o RESULTS	62,734	17.54	17.76	0.2

Note (1): FMLB is forest management land base and consists of the area remaining after exclusion of waterbodies, non-forested areas, areas with no forest cover information, protected areas, and areas that are not administered for forest management objectives.

Table 17 shows the average site indexes by species group before and after the TEM adjustment which were used in the base case. Currently, no new independent accuracy assessment has been completed for these adjustments; however such an assessment could be completed in advance of future Timber Supply Reviews on Haida Gwaii.

[17] Ran, Shikun. 2011. Final Report For the Terrestrial Ecosystem Mapping Database Adjustment on the Queen Charlotte Island Timber Supply Area. Prepared for the TSR Joint Technical Working Group. Ecora Resource Group Ltd.
[18] Model parameters were reviewed by ecologists Andy Mackinnon, Sari Saunders and Alan Banner.

TABLE 17: AVERAGE SITE INDEXES BY SPECIES GROUP

Species	Area (ha)	TEM SI (m @ 50 yrs)	TEM Calibration SI (m @ 50 yrs)
CW	88,501	16.3	16.6
HW	42,558	22.1	22.6
SS	14,785	29.2	29.4
CY	4,373	9.0	17.1
PL	2,875	6.5	17.4
DR	1,157	24.7	25.0

It is recognized that there are uncertainties regarding ecosystem mapping on Haida Gwaii. However, the existing mapping provides the best available information on site series, and therefore the best basis for applying SIBEC estimates.

Site index adjustment (SIA) study

A report outlining an SIA project that involved sampling of young stands from 9 to 61 years old on the TSA was released in 2010[19]. In general, the study involved developing preliminary SI estimates using a proprietary biophysical model, then comparing the preliminary estimates to SIs derived from field samples. SIs based on the biophysical model and field samples were substantially higher than inventory SIs. For western hemlock, the average inventory SI was 15.1 m@50 years, while the proposed adjustments provide an average potential SI of 24 m@50 years. For Sitka spruce the corresponding numbers are 17.7m and 27.8m.

While the report asserts that the adjustments derived through sampling apply across Haida Gwaii, and an adjustment file was provided for application to all forest stands in the TSA, the sampling frame included only young stands on the TSA. In addition, the SI adjustments are based in part on a relationship between the preliminary SI derived from the biophysical model and field samples, and the available data indicate that there is not a statistically significant relationship[20]. Nevertheless, an assessment was done of the effects of the adjustments from the SIA study when applied within the sampling frame indicated in the report.

For young Sitka spruce and western hemlock stands between 16-60 years, SIA estimates for the TSA were applied based upon the April 2010 Site Index Adjustment Report[21]. SIA estimates were not used for Existing Natural Stand Yield Table (NSYTE) conversions to Future Managed Stand Yield Tables as the project samples did not include NSYTE sites. SIA estimates were not used for Western red cedar leading sites as the project samples did not include a significant sample. The areas subject to Site Index Adjustment (SIA) derived site index estimates are shown in the following table.

[19] Timberline Natural Resource Group Ltd. Site Index Adjustment of the Haida Gwaii Timber Supply Area. Prepared for Ministry of Forests and Range, Forest Analysis and Inventory Branch.
[20] Personal communication, Peter Ott, Senior Biometrician at Forests, Lands and Natural Resource Operations
[21] Timberline Natural Resource Group Ltd. Site Index Adjustment of the Haida Gwaii Timber Supply Area. Prepared for Ministry of Forests and Range, Forest Analysis and Inventory Branch.

Inventory attributes
Site index can be defined using inventory attributes (height and age). As highlighted earlier, there are shortcomings associated with this approach. However, where other information is not available, use of the inventory attributes and a site index model is the best available approach. For this analysis Site Tools (version 3.3, 2004) was used to determine site index on areas for which SI could not be assigned by any of the first 3 site productivity approaches.

Challenges associated with site productivity information

The JTWG faced several challenges in identifying the best available site productivity information:

- The forest cover inventories for the islands are mostly based on old sampling. While the inventories have been projected and updated for disturbance, there is significant uncertainty about the accuracy of attributes such as height and age, which are used in deriving SI. SI based on inventory information normally constitutes a reasonable estimate of site productivity for intermediate-aged stands (30-140 years old). On Haida Gwaii, however, significant uncertainty surrounds SI estimates derived from the inventories.
- There is inconsistent ecosystem mapping coverage of the islands. Mapping of biogeoclimatic ecosystem classification (BEC) site series is needed as a basis for applying site index estimates linked to BEC (i.e., SIBEC).
- The terrestrial ecosystem mapping (TEM) for the Haida Gwaii Timber Supply Area (TSA) did not pass an accuracy assessment[22]. As will be discussed below, a TEM calibration study was undertaken, however time was not available to do an accuracy assessment on that study. In addition, incomplete information is available for much of the ecosystem mapping available on the islands. Nevertheless the TEM for TSA was used in the timber supply analysis base case since it provided the necessary basis for applying SIBEC site productivity information. It is recognized that there is uncertainty associated with this approach; however, given the well-established concerns regarding the use of inventory attributes as a basis for defining SI, it was believed that use of the available TEM information was warranted. A later section describes sensitivity analysis that was undertaken to demonstrate how timber supply changes when alternative SI information is used.

Site productivity schema for timber supply analysis
Considering the uncertainties surrounding site productivity, forecasts were generated using both base case assumptions and sensitivity assumptions described below.

[22] Timberline Natural Resource Group. 2008. Terrestrial Ecosystem mapping within the Queen Charlotte Timber Supply Area, Final Accuracy Assessment. Prepared for Husby Forest Products.

Base case

For the base case, SI was assigned using the sources indicated in Figure 5. As shown, the main source of SI was SIBEC. SIBEC derived SI estimates were used for 153,625 hectares of THLB. Stump site index adjustments were use on 38,601 hectares in the base case. RESULTS derived SI estimates were used on 16,123 hectares. Inventory attributes (i.e. SiteTools) were used on only 4,609 hectares.

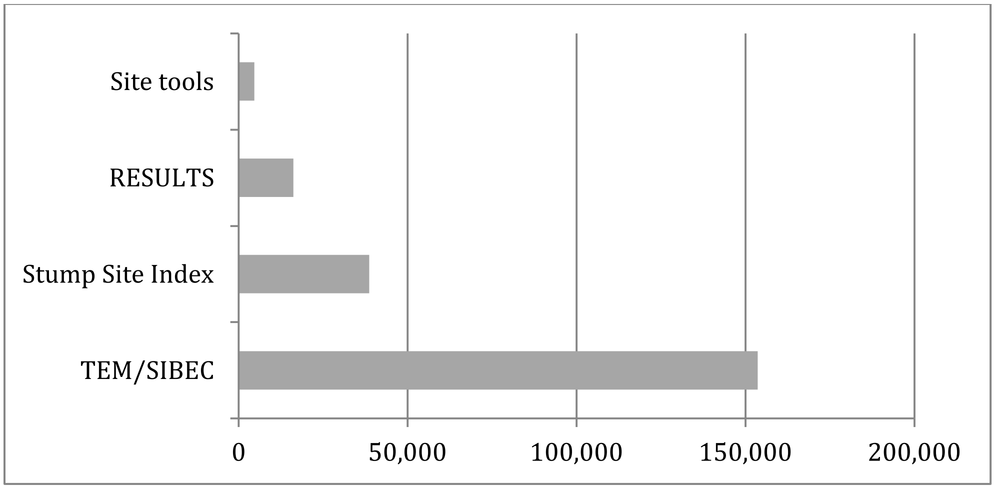


FIGURE 5. SOURCES OF SITE PRODUCTIVITY ESTIMATES FOR THE BASE CASE, EXPRESSED IN HECTARES OF TIMBER HARVESTING LAND BASE

Figure 6 provides a comparison of the SI distribution by THLB area between the inventory attribute-based SI and the SIs assigned for in the base.

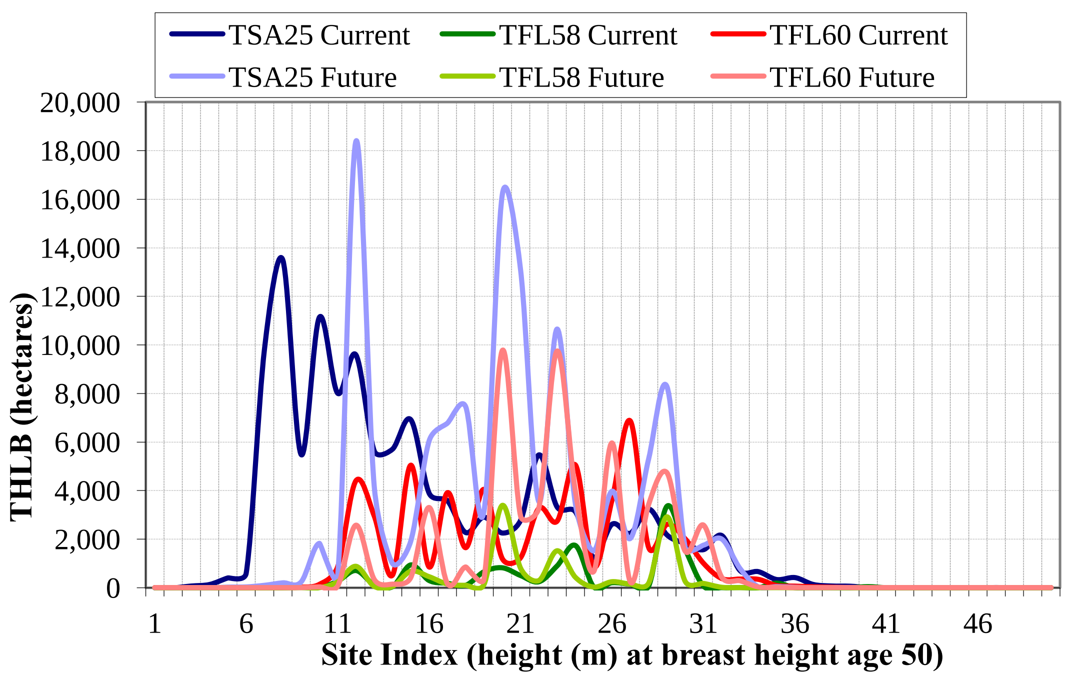


FIGURE 6. BASE CASE SITE PRODUCTIVITY DISTIRBUTION

Site productivity sensitivity analyses

Sensitivity analysis 1: Impact of applying SIs based on inventory attributes

The following assumptions on site productivity were applied:

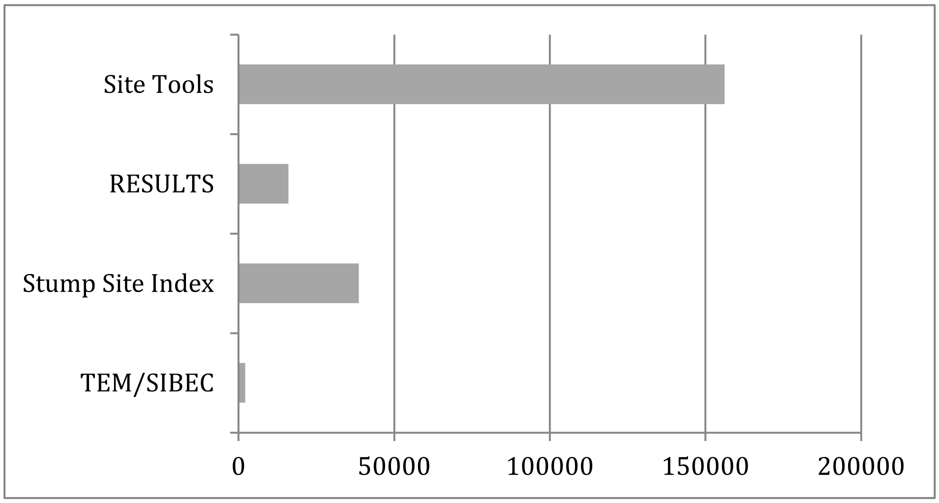


FIGURE 7. SOURCES OF SITE PRODUCTIVITY ESTIMATES FOR THE FIRSTSENSITIVITY ANALYSIS, EXPRESSED IN HECTARES

- As identified above in the base case, stump site index adjustments were used where applicable.
- The model utilizes approximately 38,601 hectares based on stump site index adjustments.
- As identified above in the base case, site index derived from RESULTS were used where applicable.
- Approximately 16,123 hectares of RESULTS derived site index estimates were used in this model.
- Site Tools (version 3.3, 2004) was used to determine site index using forest inventory attributes. Site Tools utilizes species, age, and height within the inventory to derive a site index. Approximately 156,077 hectares of Site Tools derived site index estimates were used in this sensitivity analysis.
- Ecosystem/SIBEC, as described under the base case site productivity assumption (#3 above) was used to fill in the remaining gaps. Approximately 2,156 hectares of TEM/SIBEC were used to derive site index estimates in this model.

Sensitivity analysis 2: Impact of applying SIs from the Site Index Adjustment (SIA) study

For young Sitka spruce and western hemlock stands between 16-60 years, SIA estimates for the TSA were applied based upon the April 2010 Site Index Adjustment Report[23]. SIA estimates were

[23] Timberline Natural Resource Group Ltd. Site Index Adjustment of the Haida Gwaii Timber Supply Area. Prepared for Ministry of Forests and Range, Forest Analysis and Inventory Branch.

not used for Existing Natural Stand Yield Table (NSYTE) conversions to Future Managed Stand Yield Tables as the project samples did not include NSYTE sites. SIA estimates were not available for Western red cedar since it was not part of the sample. The areas subject to Site Index Adjustment (SIA) derived site index estimates is a total THLB area of 12,634 hectares in the TSA (6.7% of the total long-term THLB and 10.5% of the long-term TSA THLB).

While advice from statisticians was that the SIA results should be applied only within the sampling frame, as described in the previous paragraph, sometimes SIA results are extrapolated across a management unit. Therefore, analysis was also done to find the difference between area-weighted average SI resulting from application of the SIA adjustments to western hemlock and Sitka spruce stands currently 100 years of age or older across the TSA (the only area for which results were provided), and the area-weighted average of SIs for the base case, which were mostly from the stump SI study. This area covers about 13,500 hectares 7.2% of the total long-term THLB and 11.2% of the long-term TSA THLB. Results of these assessments will be included in a summary report.

Inventory audit and volume and decay sampling studies

An inventory audit and a volume and decay sampling study were done on Haida Gwaii in the late 1990s. The results were published in 1999 in "Queen Charlotte Islands TSA Timber Supply Analysis Adjustment; FIP File Adjustment Process"

Inventory audit

The inventory audit involved comparing the photo-interpreted inventory attributes for the Queen Charlotte Islands TSA or TSA25 (excluding the TFLs), projected for growth, with the measured attributes of inventory audit ground plots. That study documents differences between observed data and the inventory data for tree height, age, and volume, and includes adjustment factors specific to the TSA. This study was based on the VDYP6 yield model.

Results of the audit suggested that for the TSA only (the only land base for which the inventory audit was done) there was an overall negligible difference between volumes calculated using VDYP6 based on inventory height and age and those calculated using ground sampled height and age, using the taper and decay factors that existed at the time, that is, prior to the new volume and decay study.

Volume, taper, and decay study

The second study implemented and assessed a newly developed, unbiased volume and decay sampling methodology for the entire managed forest land base of Haida Gwaii including the TFLs. This study provided refined taper equations and loss factors that permitted definition of sound-wood proportions for cedar, hemlock, spruce and cypress at the tree level, whereas the audit results applied to whole stands. Table 18, below, provides tree-level adjustment factors by tree species on Haida Gwaii. It should be noted that these factors are not stand-level adjustments, as would result from an audit. These taper and loss adjustments apply to all of the main forest management units on the islands, that is, the TSA and both TFLs.

The TSA audit suggested that the inventory attributes together with VDYP6 and the old taper and loss factors provided a statistically adequate estimate of the overall volume on the TSA. However, whenthe new taper equations and loss factors resulting from the volume and decay study were applied to the audit data using the same yield model as was used for the audit (VDYP6), the overall difference was an increase in the volume for the TSA of about 14%. These results suggested that for the TSA, errors in the height and age attributes were on balance not large enough to not cause errors in volumes. However, the study indicated that use of the old taper and loss factors would underestimate volumes.

The new taper equations and sound wood factors developed in the volume and decay study have not been implemented in the VDYP7 model. To explore the implications of using the new factors in the current version of VDYP, the 1998 inventory audit plot attributes (basal area, age, height, species composition and site index) from the TSA were projected with VDYP7. The VDYP7/audit attribute output volumes were then compared with the volumes measured in the audit plots. Large differences were observed. Again, these differences are due to "model error" (as opposed to attribute error, or errors in height and age) and are largely attributable to not having incorporated the taper equations and loss factors specifically developed for Haida Gwaii into VDYP7. This latest assessment suggests that VDYP7 underestimates the volume of cedar-leading stands older than 60 years on the TSA by approximately 55% because there is much less rot and also more gross volume in each tree than predicted by VDYP7. For hemlock-leading stands, the study suggests that VDYP7 underestimates sound wood volume by 32%. These differences apply only to the TSA, and are subject to a caveat discussed below.

Application in the timber supply analysis

While these analyses using audit data, the taper and decay study, and VDYP7 suggest that volume estimates for existing naturally established stands from VDYP7 likely underestimate actual volumes, there are caveats to the application of the study results in the analysis. These caveats led to a decision not to apply the results of the audit or the taper and loss study in the base case, but rather to do a sensitivity analysis to explore the potential impacts.

First, almost 20 years have passed since the audit study was completed. Given the amount of harvesting in old forests during that period, the applicability of the audit results to the current TSA inventory is uncertain.

Second, while the new taper and loss factors apply to all of the managed forest on Haida Gwaii, they apply at the individual tree level not at the stand level. Therefore the factors aren't strictly applicable to stand-level yield curves. Hence, the application of the taper and loss factors to stand-level yield tables – the only approach that is available for this analysis – provide a only general idea of how inventory volume estimates would change given integration of the taper and loss factors into VDYP7.

Third, while the ratios are stratified somewhat by age, the categories are broad. In reality the application of the new taper equations and loss factors would affect volumes differently at different ages and in different types of forests. Therefore, the ratios can provide only a general idea of the potential volume underestimate.

TABLE 18: VOLUME ADJUSTMENT FACTORS BASED ON NEW LOSS FACTORS AND NEW TAPER EQUATIONS

Age Group	Cedar	Hemlock	Spruce	Cypress
Immature (>60 and <140yrs)	+10%	+2%	+1%	N/A
Mature (>=140yrs)	+41%	+19%	+3%	+17%

Given these caveats, the adjustment ratios provided in Table 18 were used in a sensitivity analysis, which allows for an assessment of the potential impacts of the fact that VDYP7 does not incorporate the new taper and loss factors.

For each inventory polygon, the factors in Table 18 were blended into a single species-weighted adjustment factor based on the species percentage from the inventory file. The VDYP curve for each forest cover polygon was then multiplied by the species-weighted adjustment factor.

It is acknowledged that there may be additional errors in volume estimates due to errors in attributes (basal area, height, age), which are not accounted for by the volume adjustments based on the taper and loss factors derived from the volume and decay study. However, as discussed earlier, the overall impact of attribute error was shown to be negligible in the TSA (the only area for which attribute adjustments are available). Therefore it is believed that the volume adjustments based on the volume and decay study are adequate for applying in a sensitivity analysis, which will enable assessment of the potential timber supply impacts associated with errors in existing volume estimates based on the inventory.

Yield curves

Existing and future managed stands
The following figures represent site curves for existing and future managed stands by species. Curves were generated by the Table Interpolation Program for Stand Yields (TIPSY). Curves are aggregated by species and site index range into 31 classes for reporting purposes. Note that Analysis Units used in the model assign individual curves (2,190 curves for existing managed stands) for each polygon.

These curves replace the ones by Goudie (1984). There is little difference between the two curves; however, the new models are developed from data collected in British Columbia.

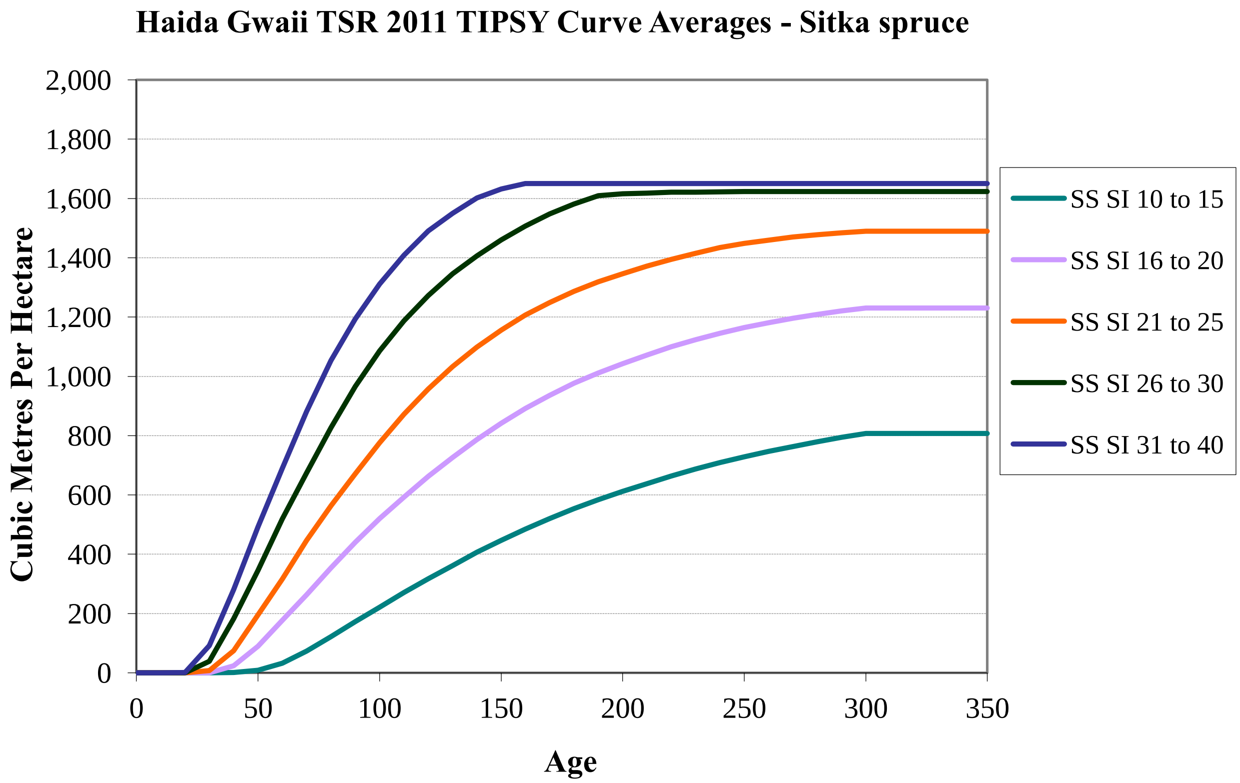


FIGURE 8. MANAGED STAND YIELDS — SITKA SPRUCE

The height-age (site index) curves for Sitka spruce were developed from 40 stem analysis plots established in ecologically uniform areas of Sitka spruce stands in the Queen Charlotte Islands[24]. All plots were in the submontane wet hypermaritime Coast Western Hemlock (CWHwh1) biogeoclimatic variant. Plot ages ranged from 50 to 121 years at breast-height and site index from 13.6 to 40.3 m.

[24] Nigh, Gordon D. 1997. A Sitka spruce height-age model with improved extrapolation properties. For. Chron. 73(3): 363-369.

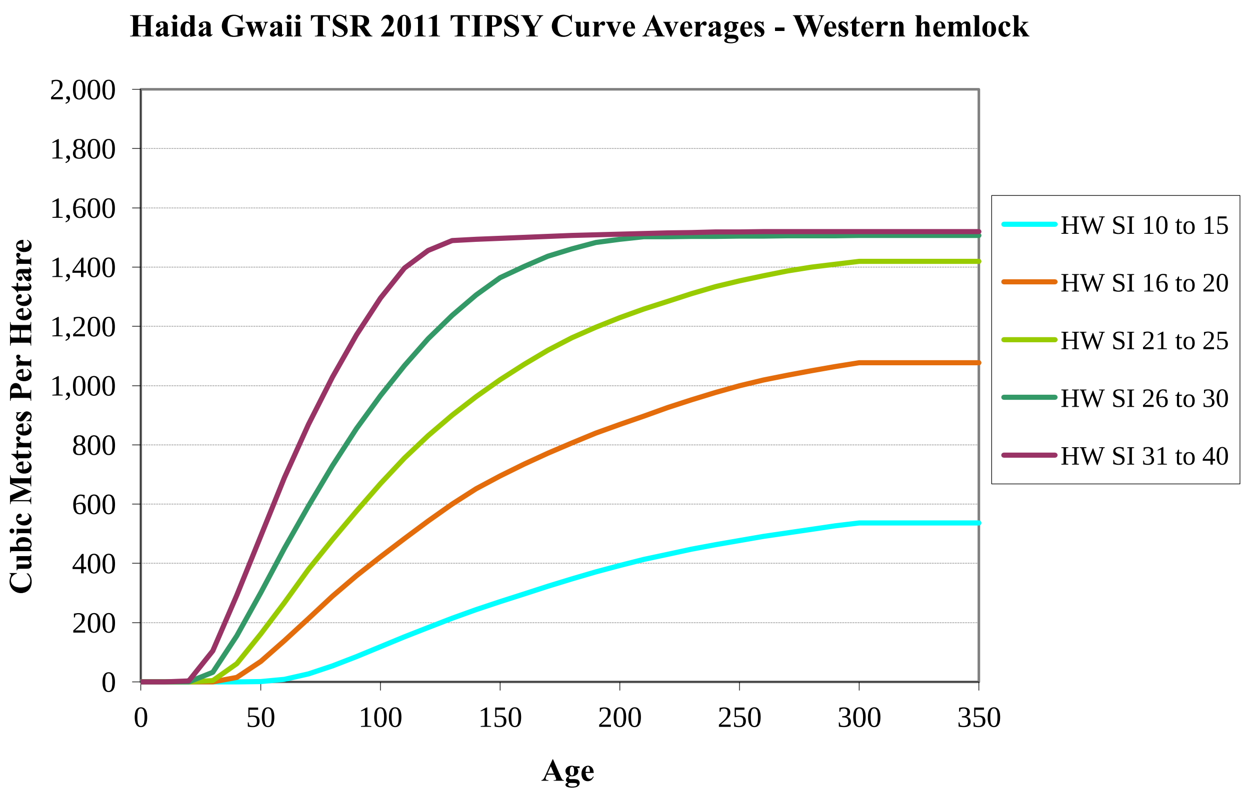


FIGURE 9. MANAGED STAND YIELDS — WESTERN HEMLOCK

The site index (height-age) curves were developed from stem analysis data collected from 90 plots in Washington and Oregon. The plots ranged from site index 18 to 40 m and from about 60 to 130 years breast-height age. The height- age equation should not be used for ages less than 10 years. In British Columbia, MacMillan Bloedel Ltd. calibrated these curves to better represent the local growing conditions[25]. Note: the formulation was modified in 2003 to move the age, height origin from 0,1.37 to 0.5,1.37.

[25] Wiley, Kenneth N. 1978. Site index tables for western hemlock in the Pacific Northwest. Weyerhaeuser Co., For. Res. Cent. For. Pap. 17. 28 p.

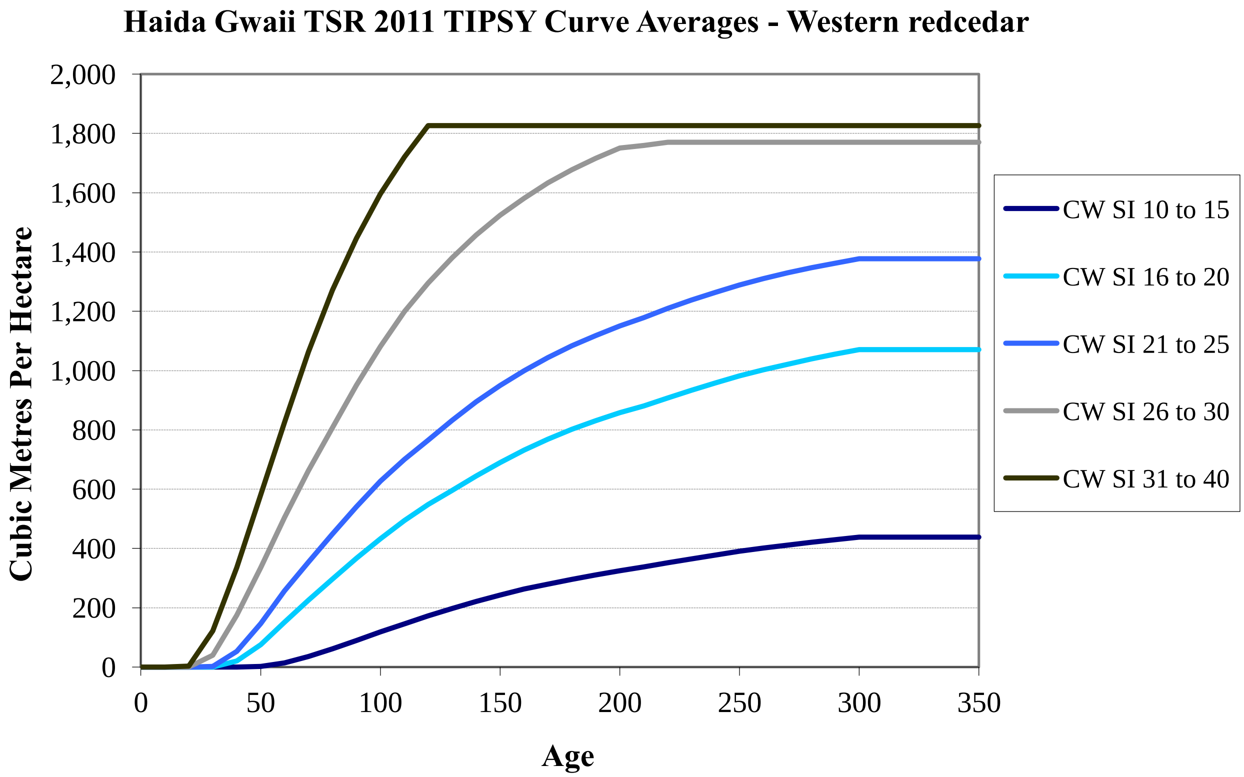


FIGURE 10. MANAGED STAND YIELDS — WESTERN RED CEDAR

This 1985 formulation is an updated version of the curves given in 1978 by Kurucz 1978. Kurucz, John F. 1978. Preliminary, polymorphic site index curves for western redcedar (Thuja plicata Donn) in coastal British Columbia. MacMillan Bloedel For. Res. Note No. 3. 14 p. + appendix.

The height-age (site index) curves were developed from stem analysis of undamaged, dominant and co-dominant trees located in approximately 50 stands throughout Vancouver Island and the mid-coast region of the mainland. The sample trees ranged in breast-height age from 33 to 285 years and in site index from 8 to 37 m. Kurucz suggested using this formulation with caution for breast-height ages less than 10 years and for site indexes greater than 37 m. Note: the formulation was modified in 2003 to move the age,height origin from 0,1.3 to 0.5,1.3.

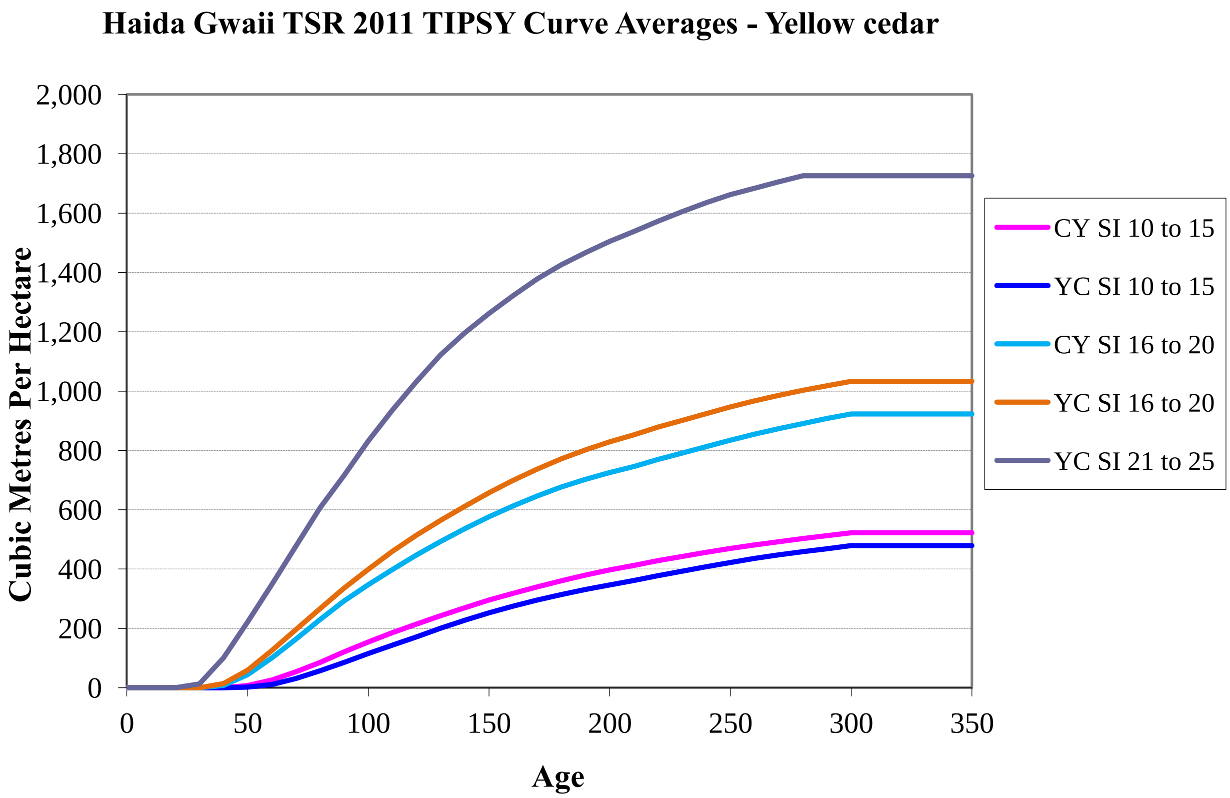


FIGURE 11. MANAGED STAND YIELDS — YELLOW CEDAR

See yield curve background information for Western Redcedar (no curve data exists for Yellow Cedar).

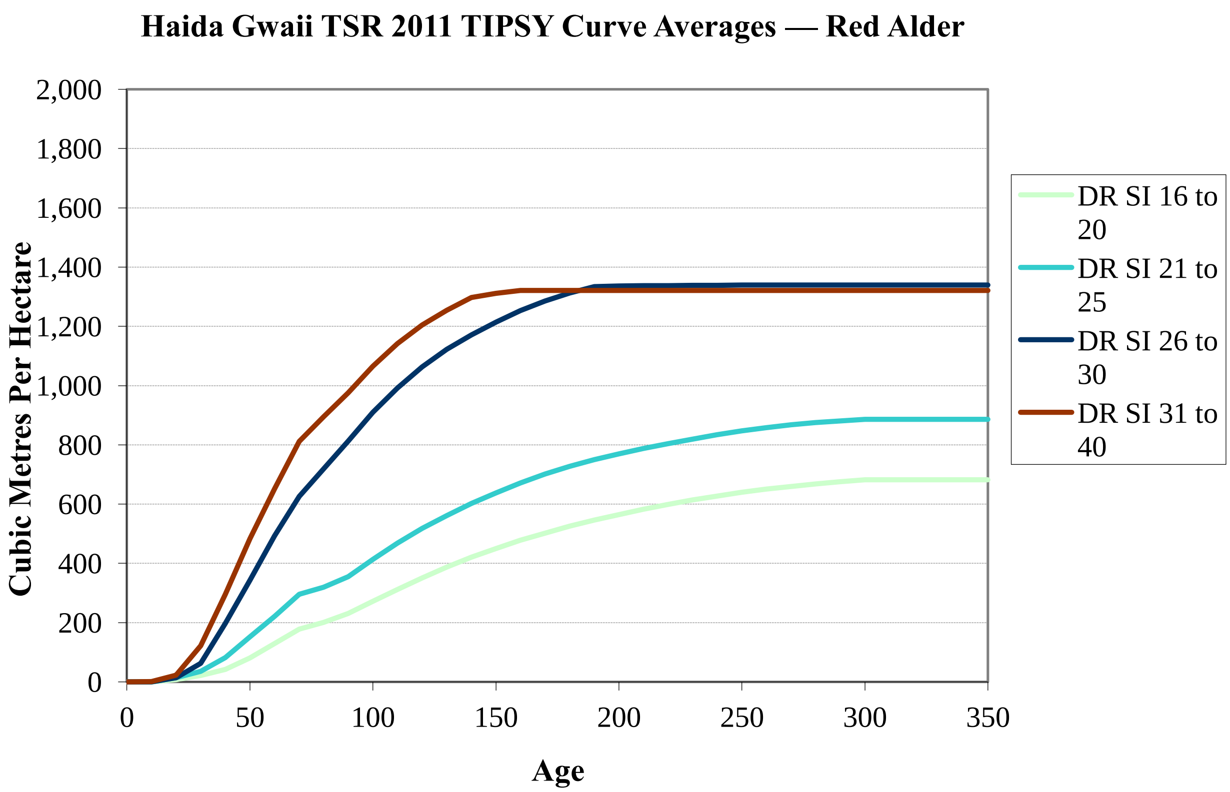


FIGURE 12. MANAGED STAND YIELDS — RED ALDER

The height-age equation was developed from stem analysis of 30 - 0.04 ha plots from natural red alder stands in the CWH biogeoclimatic zone in British Columbia[26]. Breast height ages ranged up to 54 years and site index ranged from about 15 to 28 m (at 25 years breast height age). Conversions from a breast height age 25 site index to a breast height are 50 site index are derived from the height-age model. Site index can be calculated directly by inverting the height-age model. A years to breast height model was also developed from the same data.

[26] Nigh, G.D. and P.J. Courtin. 1998 Height models for red alder (Alnus rubra Bong.) in British Columbia. New For. 16:59-70.

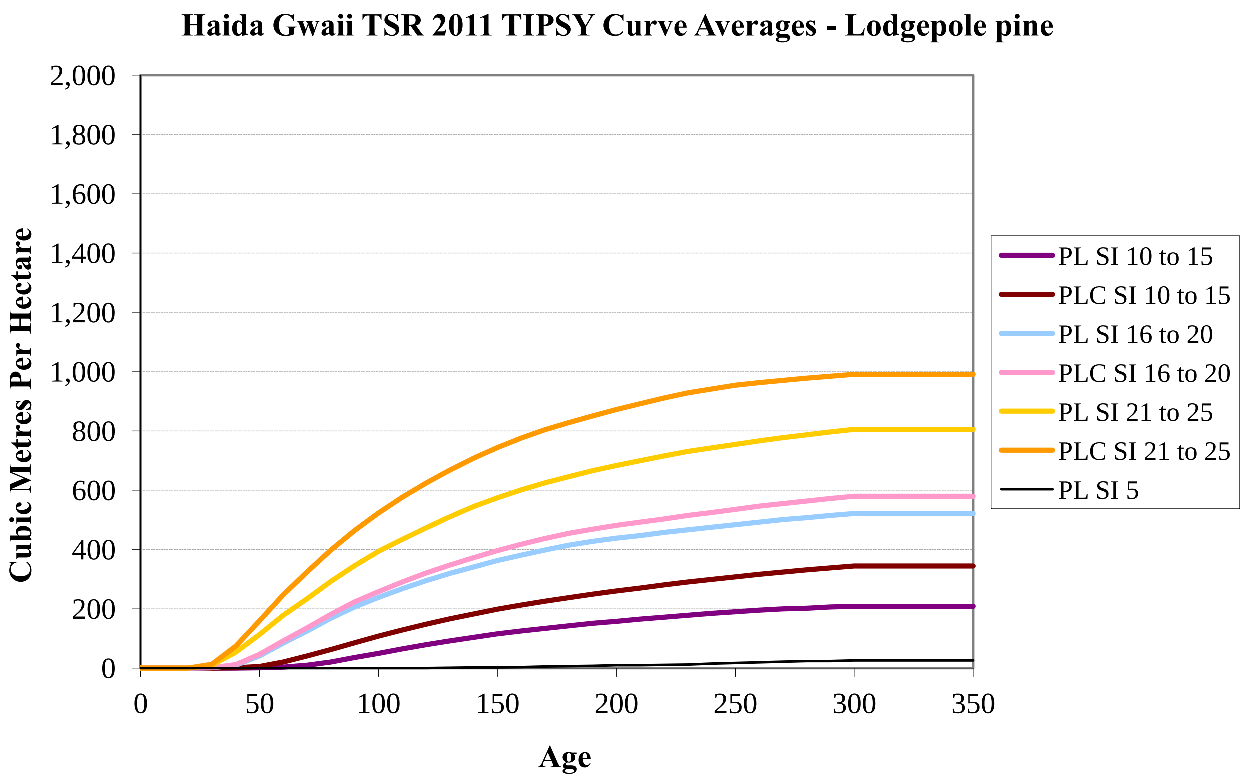


FIGURE 13. MANAGED STAND YIELDS — LODGEPOLE PINE

The height-age models were developed from 106 plots established throughout the interior of British Columbia[27]. Ages ranged from 50 to 130 years at breast height. The site indices of the plots ranged from 6 to 27 m at breast height age 50. A years to breast height model was also developed.

The height-age (site index) curves were developed from stem analysis of undamaged, dominant and co-dominant trees located in approximately 50 stands throughout Vancouver Island and the mid-coast region of the mainland[28]. The sample trees ranged in breast-height age from 33 to 285 years and in site index from 8 to 37 m. Kurucz suggested using this formulation with caution for breast-height ages less than 10 years and for site indexes greater than 37 m. Note: the formulation was modified in 2003 to move the age,height origin from 0,1.3 to 0.5,1.3.

[27] J.S. Thrower and Associates Ltd. 1994. Revised height-age curves for lodgepole pine and interior spruce in British Columbia. Report to the Res. Br., B.C. Min. For., Victoria, B.C. 27 p.

[28] This 1985 formulation is an updated version of the curves given in 1978 by Kurucz 1978. Kurucz, John F. 1978. Preliminary, polymorphic site index curves for western redcedar (Thuja plicata Donn) in coastal British Columbia. MacMillan Bloedel For. Res. Note No. 3. 14 p. + appendix.

Existing Natural stands

The following figure represent volume curves for existing natural stands by species. Curves are generated by the Variable Density Yield Program (VDYP). Curves are aggregated by species and site index ranges into 44 classes for reporting purposes. Note that Analysis Units used in the model assign individual curves (47,000 curves for existing managed stands) for each polygon.

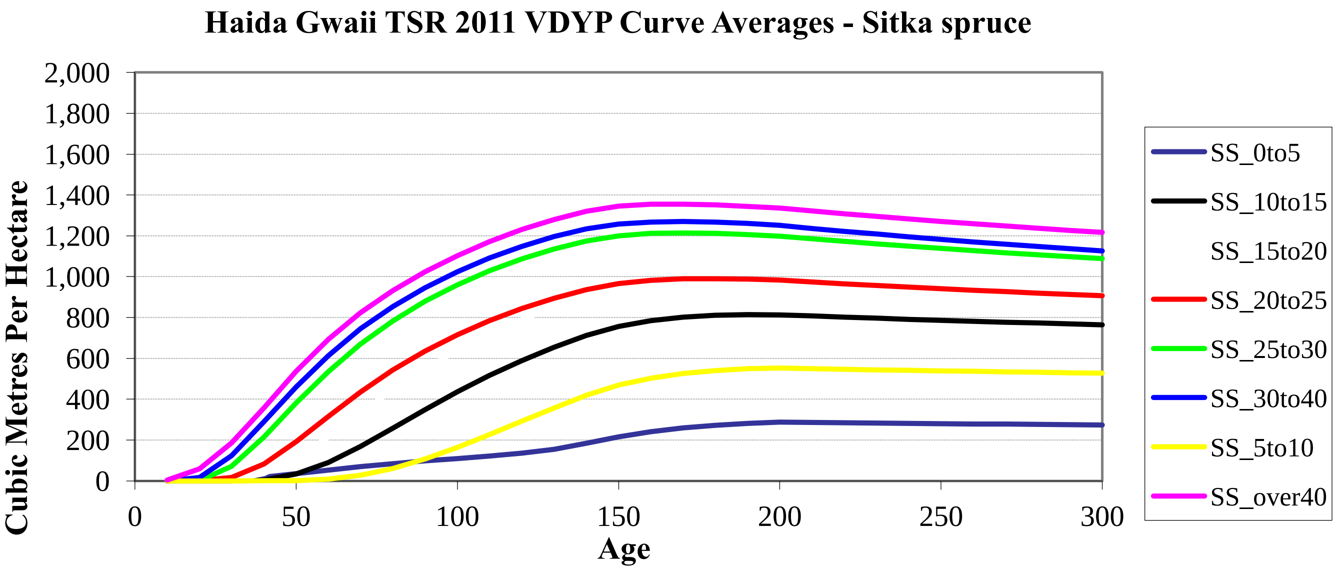


FIGURE 14. EXISTING NATURAL STAND YIELDS — SITKA SPRUCE

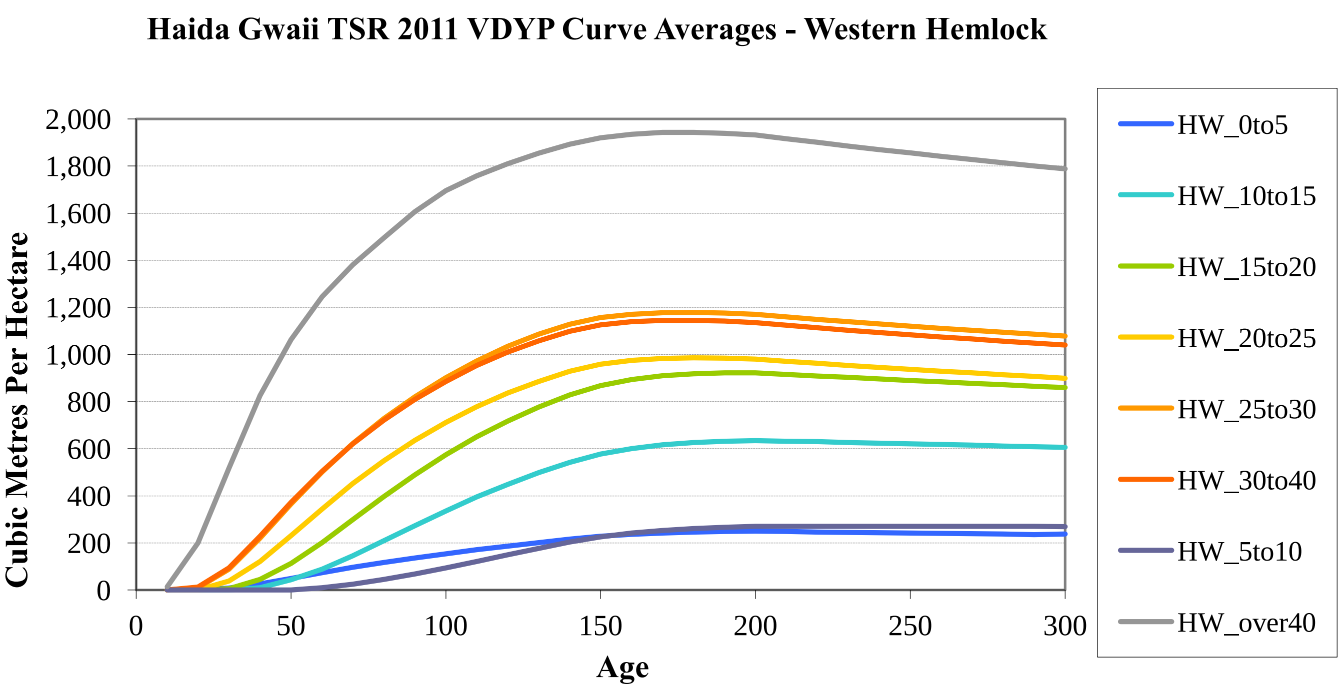


FIGURE 15. EXISTING NATURAL STAND YIELDS — WESTERN HEMLOCK

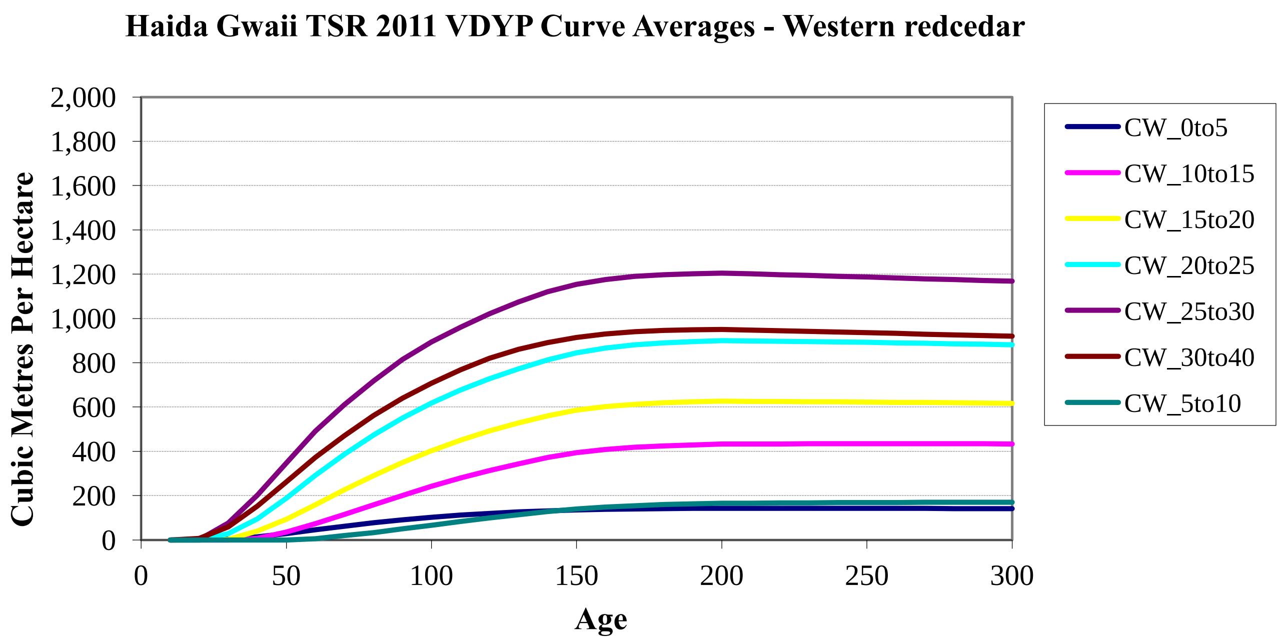


FIGURE 16. EXISTING NATURAL STAND YIELDS — WESTERN RED CEDAR

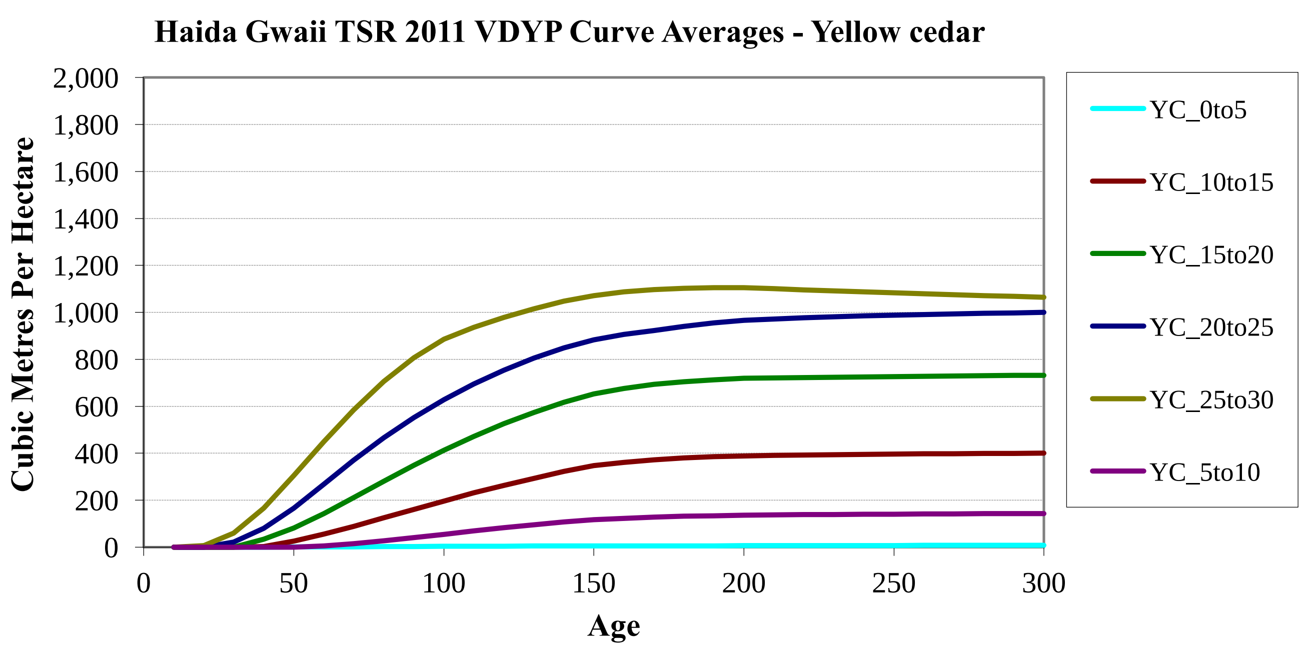


FIGURE 17. EXISTING NATURAL STAND YIELDS — YELLOW CEDAR

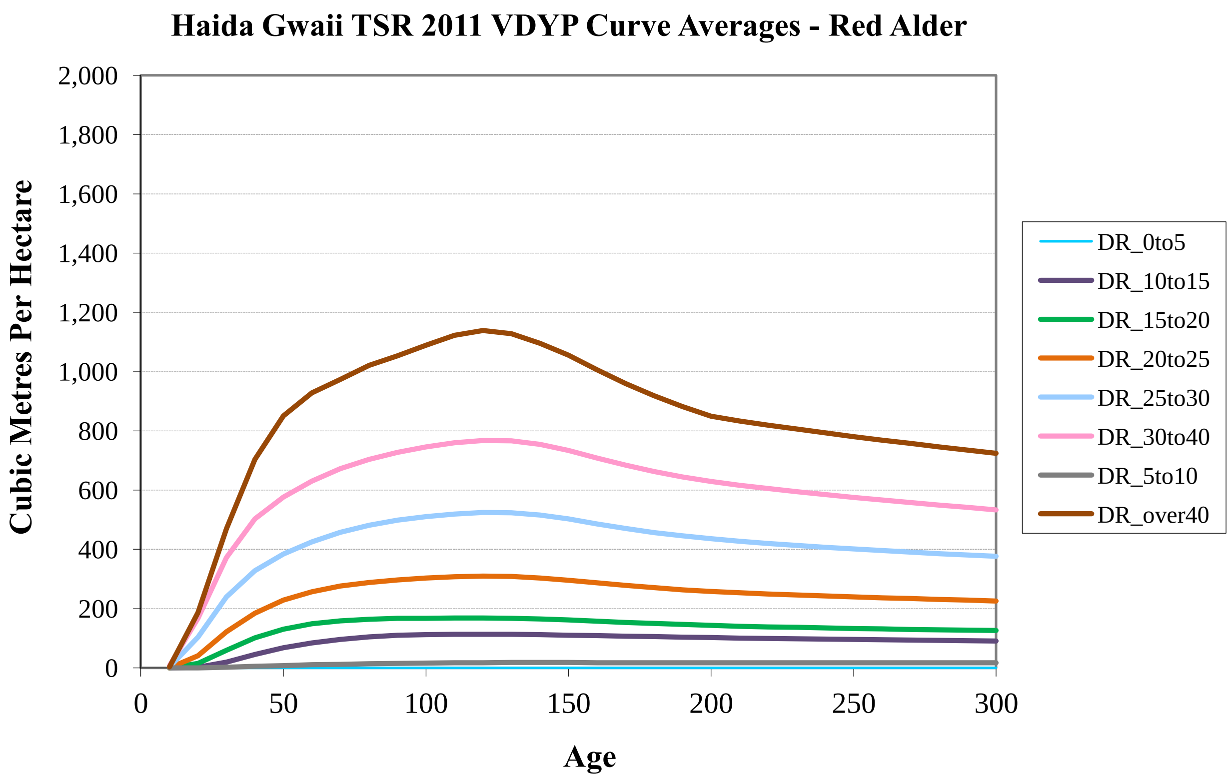


FIGURE 18. EXISTING NATURAL STAND YIELDS — RED ALDER

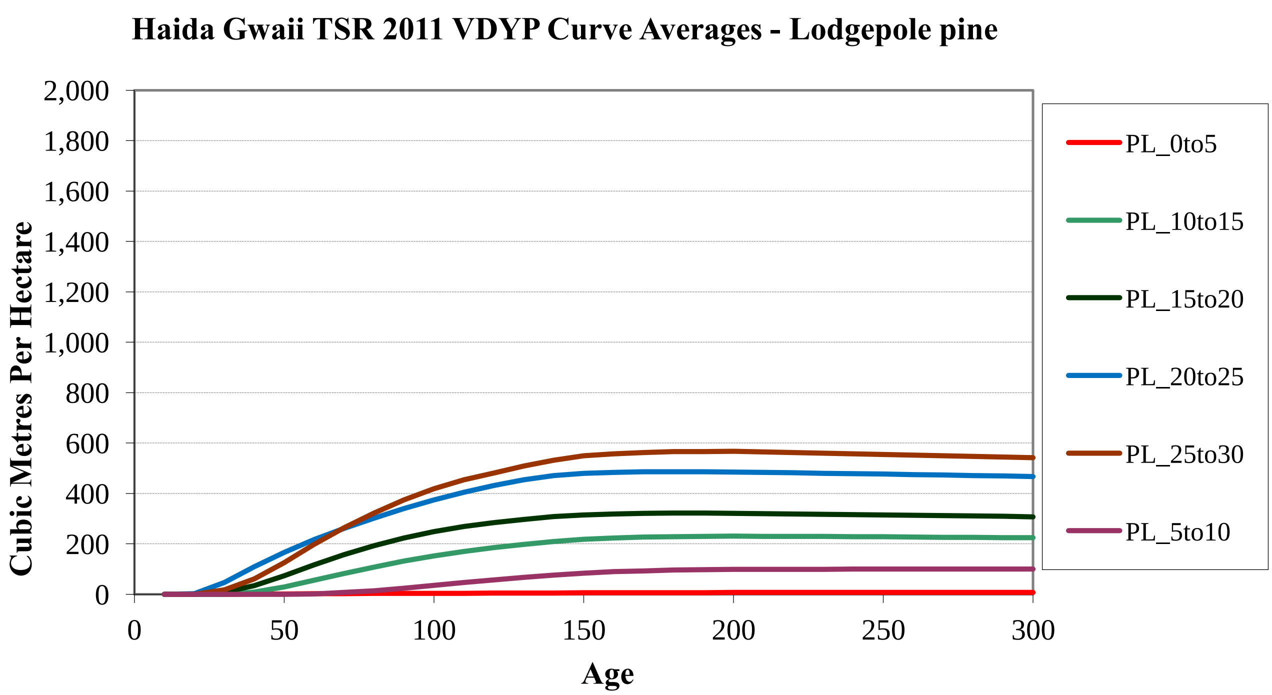


FIGURE 19. EXISTING NATURAL STAND YIELDS — LODGEPOLE PINE

Utilization levels

Utilization levels define the maximum stump height, minimum top diameter inside bark (DIB) and minimum diameter at breast height (DBH) by species for merchantable trees. Utilization levels for the analysis were a 30-cm stump, 10-cm DIB, and 12.5-cm DBH.

Decay, waste and breakage for unmanaged stands

Decay, waste and breakage for unmanaged stands was derived from default settings within the Variable Density Yield Prediction (VDYP) software model.

Operational adjustment factors for managed stands

Yield estimates provided by TIPSY (Table Interpolation for Stand Yields) represent the production from fully stocked stands that are free of disease and insects and have not been subject to damage from natural events such as wind and snow press. Operational adjustment factors (OAFs) are employed to account for these factors that reduce yields below the full potential.

In TIPSY the so-called OAF1 is a constant percentage reduction that accounts for four different types of losses: (1) small non-productive areas, (2) incomplete or irregular stocking gaps and competition from non-commercial brush, (3) endemic disease and insect losses that are relatively constant in percentage impact over time, and (4) other factors such wind throw, top damage and snow press.

OAF2 increases over time, and can be used to account for losses, for example those due to root rots, that increase in percentage over time.

The default values are 0.85 (representing a 15% loss in yield) for OAF1 and 0.95 (or a 5% loss) for OAF2. For OAF2 the 5% loss applies at 100 years of age. The OAF2 starts at 0% at age 0, increases by 0.5% per decade reaching 5% at 100 years, and continues to increase at the same rate after 100 years.

There is a substantial amount of uncertainty about these defaults since the underlying research is limited. Some studies have been done to attempt to quantify aspects of OAFs, particularly gaps in stands. However, no recent studies have been done that account for all factors that reduce yields. The best way of determining the extent to which yields fall below the ideal potential would be to monitor regenerated stands and compare actual yields to those indicated by TIPSY.

In previous timber supply analyses for Haida Gwaii management units, a variety of growth and yield OAFs have been employed. For the timber supply area analysis completed in 2000, the default OAFs were used[29]. Similarly, the most recent analysis for the TFL 58 area, completed in 2001, included the default OAFs[30]. The analysis for the former TFL 25 Block 6 employed an OAF1 of 11%

---

[29] BC Ministry of Forests. (2000). Queen Charlotte Timber Supply Area Analysis Report. (p. 127-128)
[30] JS Jones Sandspit Ltd (2001). Tree Farm Licence No. 47 Block 18 Moresby Block Timber Supply Analysis Information Package. (p. 22)

and OAF2 of 5%.[31] The lower OAF1 was used since informal surveys indicated stocking in the TFL block was very good. In TFL 60 (from TFL 39 Block 6), an OAF totalling 12.5% was used[32]. However, for TFL 39 yields for regenerated stands were generated using XENO, not TIPSY. Therefore, the operational adjustments applied for the analysis are not directly comparable to the TIPSY defaults.

In summary, there is no compelling, statistically analyzed research to suggest that values other than the default OAF values should be used on Haida Gwaii units.

Over the longer term, to ascertain better information on actual timber yields on Haida Gwaii, it would be useful to undertake monitoring of regenerated stands to allow for comparison of actual to potential yields from TIPSY or other G&Y models.

An additional useful resource for improving yield estimates is the numerous G&Y samples on Haida Gwaii specifically for Western hemlock.

Other issues related to yield table development

Permanent Sample Plots for Sitka spruce and Western hemlock on Haida Gwaii should be reviewed to determine if they can contribute to growth and yield estimates for future timber supply analyses. Localized Western redcedar growth and yield curves may be available for future TSRs (40 plots established on Haida Gwaii in 2008).

Future timber supply analyses should investigate whether shading factors should be applied to the yield curves to account for Variable Retention management practices.

6.0 Silviculture

Silviculture management regimes

Silviculture management includes practices that relate to:

- Regeneration delay
- Species composition
- Stand density
- Stand rehabilitation
- Gene resources
- Not Satisfactorily Restocked areas

Regeneration delay

Regeneration delay refers to the period of time between harvesting and the date by which an area is occupied by a specified minimum number of acceptable well-spaced trees. In addition to the time it takes to establish trees, the age of planting stock is also a factor. For example, if it takes 2 years to

[31] Western Forest Products. (2003, March). Tree Farm Licence 25 Timber Supply Analysis Information Package, Management Plan 10. (p. 50)

[32] Weyerhaeuser Forest Products. (1999). TFL 39, MP #8. Timber Supply Analysis Information Package. (p. 39)

establish seedlings after harvest, and 2-year-old seedlings are planted, the net regeneration delay is zero. Regeneration delay varies according to site and is generally correlated with site productivity. Past TSR assumptions for regeneration delay range from 1 to 8 years on Haida Gwaii.

For this timber supply analysis, the regeneration delay was set to zero years given the ease with which stands are re-established in most cases. Relevant information related to reforestation will continue to be reviewed, and if necessary the timber supply implications of changes to regeneration delay will be investigated further. However, any changes are unlikely to be more than 1 or 2 years, and any corresponding implication to timber supply would be very small.

Species composition

In general, the species composition for existing stands, whether natural (i.e., not subject to silvicultural management) or managed was based upon the existing inventory information, unless RESULTS species data were available. Species composition was assumed to be retained when the stands are harvested and regenerated in the timber supply model.

Existing young stands will regenerate on identical curves for future rotations.

The decision on whether existing natural stands, which are modeled on natural stand yield tables (NSYTE), will regenerate after initial harvest on Future Managed Stand Yield Tables (MSYTF) or Future Natural Stand Yield Tables (NSYTF) was based on findings from RESULTS.

Existing and future managed stands were assumed to result from planting as opposed to natural regeneration, which corresponds to assumptions, discussed under "stand density" below, that stems are well spaced.

Stands under 30 years old and all stands in RESULTS start on MSYTs generated using TIPSY. All other stands on NSTYs generated using VDYP7. After harvest, TIPSY stands return to TIPSY, and VDYP7 stands are regenerated on to TIPSY yield tables.

Stand Density

All stand densities were modeled using well spaced stems per hectare everywhere for existing and future managed stands (recommendations from Mario DiLucca[33] and Wendy Bergerud[34]).

Stand densities are determined for 3 categories of stands: Existing Natural Stands, Existing Managed Stands and, Future Managed Stands.

Existing Natural Stand densities

Existing Natural Stands densities were sourced from existing information within the forest inventory data.

Regeneration model for existing natural stands based on existing inventory data. Values here are grouped into site index classes for reporting purposes only.

---

[33] Growth and Yield Application Specialist. Stand Development Modeling, Forest Lands and Natural Resource Operations.

[34] , Biometrician- Harvesting and Silvicultural Practices Branch, Forest Lands and Natural Resource Operations.

Existing Managed Stand densities
Existing Managed Stand densities were sourced from RESULTS silvicultural data. The inventory (TSA VEG POLY) lists 5,820 hectares as having had juvenile stand tending treatments between 1979 an 1999. Feedback from district staff was that this area seems low given historic efforts on spacing on Haida Gwaii. Nevertheless, it was assumed that spacing treatments are reflected in stand attributes in RESULTS, which provides the best information available on silvicultural treatments.

Future Managed Stand densities
Stand densities for future managed stand yield tables were be based on findings in RESULTS. A systematic empirical approach was used whereby an area-weighted average Stems Per Hectare (SPH) was derived for groupings of tree species and site series. All SPH averages were source directly from existing managed stand data from RESULTS. These average SPH values were assigned to future managed stands based upon equivalent groupings in the existing natural stand inventory. For example, in RESULTS, a CwHwPl (CWHwh1 04) Existing Managed Stand grouping may have an average 920 Stems Per Hectare. The equivalent grouping of Existing Natural Stands in the inventory of CwHwPl (CWHwh1 04) would then have 920 stems per hectare applied to it after harvest (when it becomes a Future Managed Stand). Table 19 shows a generalized grouping for reporting purposes – actual SPH values were assigned to each individual Analysis Unit (not grouped).

Existing managed stand densities were carried over to future managed stand densities by following a priority sequence. The first priority was to match the 1st, 2nd and 3rd species and site series between RESULTS polygons and the existing natural stands in the inventory. If a match could not be made, then only the 1st and 2nd species and site series were used to link RESULTS polygons to the existing natural stands in the inventory. The following details the sequence and their proportion of THLB:

- Round 1: associating species 1, 2, and 3 and BEC site series: **103,914 ha**
- Round 2: associating species 1, and 2 and BEC site series: **49,553 ha**
- Round 3: associating species 1 and BEC site series: **27,866 ha**
- Round 4: associating BEC site series: **12,368 ha**
- Round 5: associating BEC zone: **0.5 ha**

TABLE 19. REGENERATION MODEL FOR EXISTING AND FUTURE MANAGED STANDS BASED ON EXISTING MANAGED STAND DATA. VALUES ARE GROUPED INTO SITE INDEX CLASSES FOR REPORTING PURPOSES ONLY.

Species & Site Index Class	Average Stems Per Hectare	Average Site Index
CW SI 10to15	918	12
CY SI 10to15	951	13
HM SI 10to15	903	10
HW SI 10to15	1,018	12
PL SI 10to15	882	10
PLC SI 10to15	540	13
SS SI 10to15	899	13
YC SI 10to15	781	12
CW SI 16to20	929	19
CY SI 16to20	945	17
DR SI 16to20	934	20
HW SI 16to20	938	20
PL SI 16to20	916	16
PLC SI 16to20	870	17
SS SI 16to20	907	19
YC SI 16to20	945	18

Species & Site Index Class	Average Stems Per Hectare	Average Site Index
CW SI 21to25	1,144	21
DR SI 21to25	795	23
HW SI 21to25	931	23
PL SI 21to25	589	21
PLC SI 21to25	1,085	22
SS SI 21to25	943	24
YC SI 21to25	677	25
CW SI 26to30	909	28
DR SI 26to30	996	28
HW SI 26to30	908	28
SS SI 26to30	942	29
CW SI 31to40	673	35
DR SI 31to40	1,004	32
HW SI 31to40	1,073	32
SS SI 31to40	919	32
PL SI 5	948	5

Stand rehabilitation

Other than the juvenile spacing mentioned above under *Existing managed stand densities*, there have been no recent brushing treatments on Haida Gwaii and there are no anticipated treatments

RESULTS data shows that around 11,000 ha were brushed between 1984 and 2007. It was assumed that stand attributes in RESULTS reflect these treatments. Historically, the objective of brushing was alder control. Now the nitrogen-fixing characteristics of alder are recognized, alder has some market value, and post-harvest soil disturbance is lower than in the past which makes conditions less favourable for alder regeneration so brushing is not a common treatment on Haida Gwaii.

Gene resources-use of select seed

No genetic worth is applied for any species on any curve based on recommendations from the Tree Improvement Branch[35].

There is currently no tested material (select seed) for Haida Gwaii. Historical seed use records indicate there has been some material planted with a GW of 2; however, that material although selected to establish orchards, was never tested (no breeding program for mid and north coast, including Haida Gwaii). The majority of the coastal species are tested for lower latitudes (Cw, Hw , Yc: 48-52; Ss: 48-54, not including Haida Gwaii).

Silviculture history

Stands aged 30 years and younger were assumed to be managed stands, and were assigned yields using TIPSY.

Backlog and current not satisfactorily restocked (NSR)

NSR refers to an area not covered by a sufficient number of well-spaced trees of desirable species. The framework for stocking standards is defined in the *Forest Planning and Practices Regulation*. Areas harvested prior to October 1987 and not yet sufficiently stocked according to standards are classified as backlog NSR. Areas harvested or otherwise disturbed since October 1987 are classified as current NSR.

NSR lands were identified in RESULTS, consisting of approximately 3,700 hectares within the area of interest for TSR. There were an additional 13,000 hectares (not overlapping with the RESULTS NSR data) of NSR classed lands that were sourced from a previous timber supply analysis resultant[36]. This resultant was a compilation of forest inventory data across tenures and was used in various LUP timber supply analyses beginning in 2004.

Discussions with Haida Gwaii District staff indicated that backlog and current NSR lands should be considered to contribute to the long term timber supply due to the growing environments of Haida Gwaii. As such, species and age information was available for 14,000 hectares of the integrated NSR data so that site index could be derived as an input for TIPSY. An outstanding 2,700 hectares did

---

[35] Leslie McAulay, Decision Support Officer, Tree Improvement Branch, Ministry of Forest Lands and Natural Resource Operations.

[36] Timber Supply Analysis resultant from Cortext Consultants called CIT_EGSA_QCI.shp

not have species or age information and so these records were populated based upon personal communication with HG district staff[37] as having 900 stems per hectare and a species composition of 40% Western hemlock, 30% Western Red Cedar, and 30% Sitka Spruce. Site indexes for stands on these 2,700 hectares were assigned based upon ecosystem mapping and SIBEC.

Therefore no lands were netted out of the Timber Harvesting Land Base as not satisfactorily restocked.

7.0 Resource management

Volume exclusion

In timber supply analyses, the component of the stand volume consisting of deciduous species is excluded from overall stand volume estimates, if those species are not harvested and billed. Harvest Billing System data for Haida Gwaii from 1995 to 2010 was summarized with the intent of determining what proportion of deciduous species (red alder) made up the total volume harvested.

The volume billed over that period shows that red alder represents approximately 1% of the total billed volume. Similarly an analysis of its distribution in the forest inventory within the EBM operating landbase (excluding protected areas and private lands) shows that alder makes up approximately 1% of that inventory. Therefore it can be assumed that this species has been harvested at the same level that it exists in the inventory. Furthermore, trends in relation to tenure and harvest rates do not correspond with past TSR assumptions for different management units.

For these reasons, there were no volume exclusions based upon species.

Unsalvaged losses

Unsalvaged losses are the quantification of the average unsalvaged timber losses that occur due to biotic (insect/disease) and abiotic (fire/slides/windthrow) events. The average unsalvaged losses that occurred due to insect and disease epidemics, fire and blowdown was sourced from the MFLNRO forest health programs' aerial overview survey data on Haida Gwaii from 2006-2010.

TABLE 20. FOREST HEALTH OVERVIEW SURVEY SUMMARY OF LOSSES (HA) FOR HAIDA GWAII

	Type*	**2010**	**2009**	**2008**	**2007**	**2006**
Total Defoliators=	**IDH**	565	119	0	0	0
	IAS	0	0	0	24	39
Total Abiotics=	**NCY**	33	6	846	846	139
	NW	86			46	
	NS	101				
Total losses (ha)=		785	125	846	916	178

Notes: * IDH= black headed budworm, IAS= Green Spruce Aphid, NCY= Yellow Cedar Decline, NW= Windthrow, NS= Landslide.

[37] Mark Salz and Greg Wiggins May 31st –June 1st 2011.

Losses account for the Resource Practices Branch mortality severity codes (ranging from Trace <1% attack to Very Severe >50% attack).

Losses attributed to the western black headed budworm (*Acleris gloverana)* are assumed to result in a mortality rate of 3.6%[38]. The last outbreak for western black headed budworm occurred between 1996 and 2001. Outbreaks began again in 2008, which corresponds with the 12-16 year frequency in coastal outbreak cycle[39], with defoliation in one stand lasting for 2 to 3 years. Based on this, average losses attributable to the black headed budworm were determined over the 2009-2010 outbreak (342 ha) and averaged over a 12 year period, assuming a 2 year rate of infection, amounting to an average annual mortality rate of 57 hectares.

An assessment of the impacts from western blackheaded budworn in second growth hemlock was conducted in the spring of 2011 by forest entomologists Lorraine Maclauchlan and Jennifer Burleigh. This assessment suggests a potentially much higher mortality rate than previously recorded especially for thinned stands younger than 30 years. Further observations and reporting will contribute to future TSR assumptions for losses. By 2010 the outbreak extended to cover 97,497 hectares on Moresby Island[40]

Losses attributed to the green spruce aphid (*Elatobium abietinum)* are assumed to result in a mortality rate of 10%[41].

Leading abiotic losses are attributed to yellow cedar decline. Note that windthrow, either localized or catastrophic, while considered a major disturbance type on Haida Gwaii, was not quantified in the forest health aerial overview surveys for 2006, 2008 and 2009. Increases in storm frequencies, due to climate change, may increase catastrophic events and as such may require more detailed consideration and quantification in future TSRs.

While the 5 years of aerial overview data encompassed all of Haida Gwaii, the TSR analysis isolated the Crown Forest Land Base (CFLB), and subsequent losses within the Timber Harvesting Land Base (THLB). A spatial assessment was conducted using the 2010 Forest Health Aerial overview polygon data along with the model resultant file (including THLB proportions and species composition). The following summarizes methods to derive losses in the THLB:

a. Forest health (FH) data was overlapped with the model resultant (THLB/species)

b. Each polygon was quantified for THLB contribution;

---

[38] Nealis, V.G. R. Turnquist. 2010. Impact and recovery of western hemlock following disturbances by forestry and insect defoliation. Forest Ecology and Management 260 (5): 699-706.
[39] Shepard, R.F., Gray, T.G., 2001. Comparative rates of density change in declining populations of the balckheaded budworm *Acleris gloverana* among different sites on Vancouver island. Environmental Entomology 30, 883-891.
[40] Maclauchlan, L. J.Burleigh. 2011. Assessment of Western Blackheaded Budworm in second growth hemlock on Haida Gwaii. Unpublished report for the Ministry of Forests, Lands and Natural Resource Operations.
[41] Koot, H.P. 1991. Spruce Aphid. Forestry Canada, Forest Insect and Disease Survey, Forest Pest Leaflet No. 16; p.4.

c. Affected areas were multiplied by the 'severity codes' contained within the FH data (low=5%, med=20%, sever=40% affected)

d. If the loss was attributable to a particular tree species (*i.e.* Yellow cedar decline only affecting yellow cedar, or black headed budworm only affecting western hemlock), then the area affected was multiplied by the species composition of the polygon.

Here is a hypothetical example of this calculation:

- a 10 hectare polygon has 10 ha of Crown Forest Land Base and only 8.5 ha of THLB (85% of the polygon is THLB)
- the same polygon is affected by black headed budworm and has a severity code of M (20% affected).
- the same polygon is made up of 60% Hw.
- The mortality rate to Hw is 3.6%.
- The 'loss' in this scenario would be calculated as (((10*0.85)*.2)*.6)*.036=0.03672 ha could be considered 'loss'.

The ratio between total Haida Gwaii losses versus total THLB losses was determined using the 2010 spatial data and the average extrapolated to the other years. For example, 83% of losses occurred outside of the THLB in 2010. When using this 2010 spatial adjustment factor, the average losses between 2006 and 2010 amount to 110 hectares of Timber Harvesting Land Base per year.

It was assumed that 5% of the losses will be salvaged, with the result being an estimated average annual unsalvaged loss of a total of 104.5 hectares. Defoliation and abiotic losses such as yellow cedar decline or top-kill from defoliators are considered to be in isolated stands or stems and therefore limited amounts of salvage are considered to be viable.

TABLE 21. UNSALVAGED LOSS ESTIMATE FOR HAIDA GWAII

	Average Losses (ha)	Proportion of losses on THLB	Avg THLB Loss (ha/year)	Average Volume per Ha (m^3)	Vol Loss (m^3/year)	Unsalvaged Loss (less 5% recovery) (m^3/year)
Defoliator	**149.4**	17%	25	**344**	8,737	8,300
Abiotic	**420.6**	17%	72	**539**	38,540	36,613
TOTAL					47,276	***44,913***

The total loss was divided among the three management units according to their contribution to the THLB (64% in TSA 25; 29% is in TFL 60, 7% in TFL 58)

TSA25: 44,913*0.64=28,744 m^3/year

TFL60: 44,913*0.29=13,025 m^3/year

TFL58: 44,913*0.07=3,144 m^3/year

Biodiversity

Stand-Level biodiversity
Stand level biodiversity is anticipated to be managed for and met by the suite of other EBM value reserves such as riparian, cedar, rare ecosystem or wildlife retention areas. Stand-level biodiversity is not an explicit objective set by government or the Haida Nation on Haida Gwaii. It is also anticipated that the section 66 requirement under the Forest Planning and Practices Regulations for Wildlife Tree Retention will be incidentally met through retention set out to meet other EBM objectives and therefore has not specifically been modeled in this TSR.

Note that it was not possible to account in a spatially explicit manner for some EBM objectives due to a lack of inventory information. These values include Class 2 forest features, western yew patches and bear dens. To account for these values, a general 5% area exclusion was applied at the stand-level. This exclusion acknowledged the contribution of other EBM reserves according to the following methodology. The 5% net down was applied using a 'random distribution assumption'; that is it was assumed that the 5% net down should be equally distributed throughout a harvest unit. For example if 40% of a development area is made up of EBM reserves, then only 3% of the 'harvestable' portion of the development area would be netted down for this general stand level provision (i.e., 2%, or 40% of 5% would be attributed to the existing reserves in the development area).

Watersheds

Community watersheds
Community watersheds are watersheds with objectives that have been legally designated under the Forest Planning and Practices Regulation (Sec. 8.2). A forest cover requirement was assigned to the Honna, Jervis, Slarkedus and Tarundl watersheds so that no more than 10% of each watershed area can be younger than 10 years.

TABLE 22. COMMUNITY WATERSHED HECTARES WITH FOREST COVER REQUIREMENT

Community Watershed	Gross	THLB
Honna	4,783	2,157
Jervis	1,633	472
Slarkedus	503	281
Tarundl	998	510

Visual quality management

For the analysis, visual landscape inventory information from the LRDW was used. Specifically, areas subject to management for visual quality were identified as follows:

WHSE_FOREST_VEGETATION.REC_VISUAL_LANDSCAPE_INVENTORY = VLI.

VLI.REC_EVQO_CODE where in (m,r,pr)

TABLE 23. AREAS SUBJECT TO VISUAL QULAITY OBJECTIVES, AND FOREST COVER REQUIREMENT

REC_EVQO_CODE	Total area (hectares)	Current THLB (hectares)	Max % of area allowed below 6m
M	48,232.2	22,678	25
P	90,728	32,445	15
R	11,519	3,868	5

For each VQO polygon, the area-weighted average age at which a 6 metre visual green–up height would be achieved was calculated and applied as the modelling constraint.

There were 558 of these constraints for 528 VLI_POLYGONS. Several visual management polygons crossed landscape unit boundaries and were therefore split.

8.0 Timber harvesting

Minimum harvestable age

The minimum harvestable age (MHA) is the youngest age at which the timber supply forecasting model is allowed to harvest a stand. It is an approximation of how long it takes a stand to reach a harvestable condition.

MHA is an important determinant of timber supply since to a large degree it defines the period of time over which existing stocks need to be metered out while waiting for regenerated stands to achieve merchantable condition.

MHAs are set in different ways such as according to minimum harvest criteria which can include minimum volume per hectare, minimum average stem diameter. a minimum projected stand value, or an optimum rotation age aimed at maximizing productivity.

It is recognized that the actual timing of the future harvesting of a stand is uncertain. However, minimum harvest age is a required input for timber supply analysis, otherwise stands could be forecast for harvest in the model even at very young ages. This would not be realistic since in actuality stands will not likely be harvested until they are of merchantable volume and/or quality. Further, since the highest long-term harvest level can be achieved by harvesting stands when they have reached their maximum average productivity (volume divided by age), lack of some restriction on timing of harvest would also likely result in forecasts in which long-term harvest levels are far below the maximum.

For the base case of this analysis, MHAs were set at the earliest age by which 95% of culmination (or maximum) mean annual increment (CMAI) is achieved. CMAI is also known as the biologically optimum rotation age.

Mean annual increment is stand volume divided by stand age. The point when a stand reaches its maximum is referred to as the culmination age. Consistently harvesting stands at CMAI, if that were possible, would result in the maximum average harvest over the long term.

However, if the MHA were set at the age of CMAI, most modeled harvesting would actually after CMAI due to harvest flow requirements. That is, harvest of many stands would be delayed to ensure a consistent flow of timber supply over time. By setting the minimum age at a bit younger than culmination, the likelihood is increased that many stands can be harvested within 5% of CMAI, whereas if the minimum age were set at culmination age, some stands could be harvested as 10% past CMAI or more. Base case MHAs are summarized in Tables 24 and 25.

TABLE 24. MINIMUM HARVESTABLE AGES FOR MANAGED STANDS. 95% CMA

SI Class	Average MHA					
	CW	DR	HW	PL	SS	YC
0 to 5				290		
10 to 15	146		169	153	149	155
16 to 20	110	91	118	99	112	114
21 to 25	96	80	100	92	100	100
26 to 30	90	75	87		84	
31 to 40	80	66	75		76	

TABLE 25. MINIMUM HARVEST AGES FOR NATURAL STANDS 95% CMAI

SI Class	Average MHA					
	CW	DR	HW	PL	SS	YC
0 to 5	783		416	614	317	876
6 to 10	153	731	145	138	145	225
11 to 15	114	58	121	96	121	122
16 to 20	96	45	103	80	101	108
21 to 25	84	43	82	79	86	91
26 to 30	73	37	70	88	71	80
31 to 40	80	37	69		65	
Over 40	110	51	46		66	

In several cases, the MHAs for managed stands are greater than for natural stands, which initially seems counter-intuitive, since one would expect managed stands to grow more quickly. First, MHAs for natural stands are not especially relevant for this TSR because most are already beyond MHA.

Second, the mean annual increments for managed stands at the MHAs shown above are significantly higher than for natural stands. So, while the MHAs may be higher for managed stands, the stand volumes at harvest age are higher. VDYP (natural stand) curves tend to be a bit steeper in the early years than TIPSY (managed stand) curves but reach a bit lower plateau. This can by observed by reviewing the yield curves presented earlier. Figure 20 below graphically demonstrates this difference. While there are some outliers, in general the TIPSY MAIs are higher for a given harvest age than for VDYP.

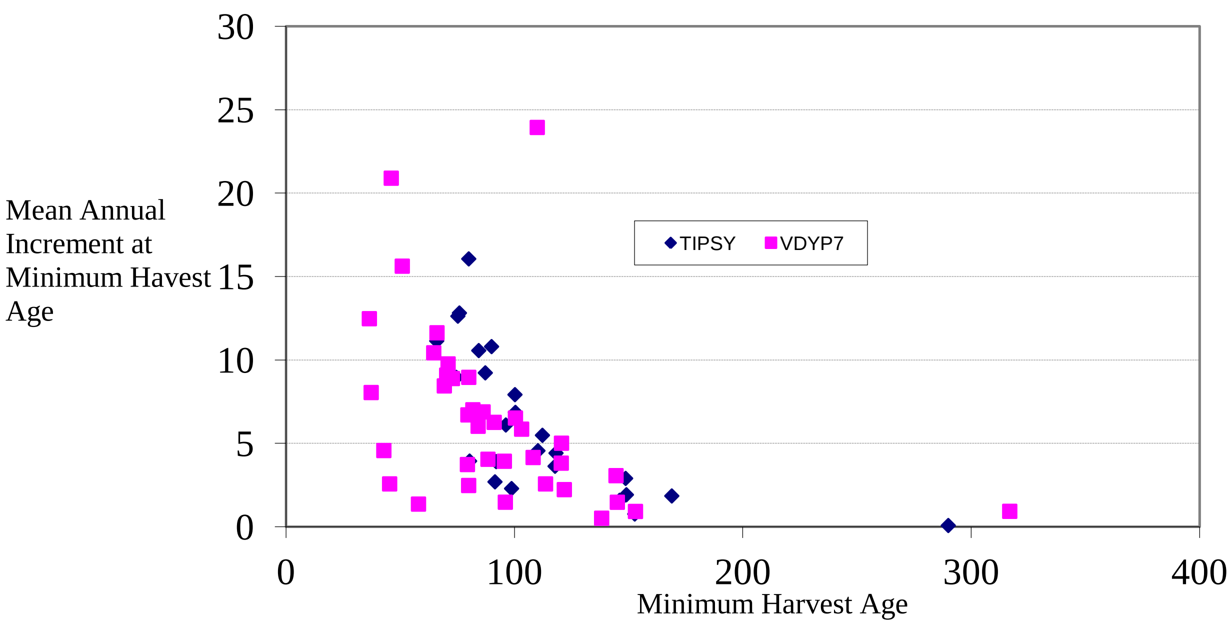


FIGURE 20. TIPSY AND VDYP'S MINIMUM HARVESTABLE AGES(MHA) VS. MEAN ANNUAL INCREMENT AT MHA

Sensitivity Analyses

As mentioned above MHA is an *approximation* of how long it will take a stand to reach harvestable condition. Various approaches are available for defining MHAs including:

(1) Maximizing productivity. MHA can be defined as an age close to that at which maximum (or culmination of) mean annual increment (CMAI) is achieved. Ninety-five percent (95%) of CMAI is frequently used.
(2) Volume as a proxy for merchantability. A minimum stand volume threshold can be applied to approximate timing of merchantability (typically done in past TSRs on Haida Gwaii).
(3) Wood quality or product targets. Some growth and yield models project the amount of wood in different grades. In addition, some studies have found a correlation between wood grade and log size. Therefore, to represent objectives for wood quality, MHA can be defined

as the age at which a stand is expected to achieve a specified average log size (e.g. diameter) or the age at which a specified proportion of the stand reaches a certain grade profile.

(4) Economic analysis. A monetary value is assigned to timber, and a discount rate is applied to define the optimal age at which to harvest a stand type. The MHA can be defined using the optimal economic rotation as a guide.

The time at which a stand will be harvested is highly uncertain due to uncertainties about future market demands for wood of different species and quality, and about forest industry strategies to meet those demands. Further, while 2nd growth is beginning to contribute to harvests on Haida Gwaii, experience with harvesting in younger stands is limited.

Given these uncertainties, examination of the implications of changes to MHAs relative to the base case is warranted.

A pair of sensitivity analyses were run in which the base case MHAs were increased and decreased by 20%. The following discussion provides some context and justification for this approach to sensitivity analysis.

<u>Product-based and economic approaches to defining minimum harvest age</u>

This section contains a summary of the results of an analysis done to explore the how product-based and economic approaches could affect the determination of MHAs. While the analysis began with a focus on the age at which stands produce higher quality wood, it also has utility in assessing the implications of a focus on obtaining revenue from a stand at as young an age as possible.

The *product-based approach* generally stems from a concern that MHAs should be defined in a way that ensures the quality of the wood will be high enough so that logs are merchantable. Some people on Haida Gwai have expressed concern that current AACs and the timber supply analyses on which they are based assume that trees will be harvestable at ages that are too young to be confident that they will be marketable. The outcome of such assumptions could be that existing stocks of old-growth timber would be harvested before second-growth trees with high enough timber quality to be marketable are available in sufficient volume to maintain harvests. In other words, the concern is that short harvestable ages could lead to higher harvesting in the short term at the expense of sustainable supplies further into the future. Therefore, one perspective on defining MHAs is that they should be based on achievement of a threshold of timber quality or grade.

As summarized above the *economic approach* to defining MHA analysis involves assigning a monetary value to timber and applying a discount rate to define the optimal age at which to harvest a stand. Use of a discount rate tends to decrease MHAs since the present value of future revenues decreases the further into the future the harvest is.

MHA assessment approach

The assessment of the implications of a product focus on MHA was based on recent harvest history for Haida Gwaii from the Harvest Billing System, and on volume and log grade outputs from the TIPSY growth and yield model.

While it is not possible to define the grade composition of harvests that would ensure future marketability, one approach is to use past harvests as a basis, since historic harvest provide an empirical basis for defining merchantability. Therefore, the first step was to examine the grade distribution of historic harvests in Haida Gwaii.

The initial plan was to focus on the age at which higher-quality logs constitute a significant proportion of stand volume; therefore attention was first given to H and I grades, since those are the highest grades for which the TIPSY growth and model provides predictions. However, in a preliminary review of the idea of examining grades as a basis for defining MHAs, licensees commented that in actuality stands are being harvested as soon as they contain a significant proportion of J-grade logs. Therefore the historic contribution to harvests of J grade and better logs was also determined.

The following table shows the range of percentage contributions of various higher quality log grades to harvests over the period from 2000 to 2010.

TABLE 26: PERCENTAGE OF HARVEST BY GRADE FOR HAIDA GWAII DISTRICT (2000-2010)

Species	Percent harvest from H grade and better	Percent harvest from I grade and better	Percent harvest from J grade and better
Hemlock	21-22	31-33	59-66
Sitka spruce	34-38	54-56	75-81
Western redcedar	27-29	40-43	63-65
All species	25-27	38-41	64-68

Source: Harvest Billing System

The ranges displayed in this table resulted from ascertaining the percentage of harvests over the 10-year period from 2000 to 2010, and also from the five-year period from 2006-2010. As the table demonstrates, the differences between the percentage harvests over the two periods are not large. These grade contribution levels provided some context for reviewing predictions from the TIPSY growth and yield model of stand-level grade composition over time.

The next was to generate timber yield tables for comparison with the historic harvest data. The TIPSY model was used to generate log grades tables for 30 stands randomly chosen from the Haida Gwaii THLB.

Very few of the 30 samples stands were predicted to achieve a composition of 25% H grade. Therefore, that threshold did not appear to be a suitable basis for further exploration.

The table below also shows the average ages for achievement of various percentage contributions of higher grade logs to the stand volume. The historic harvest levels were used as a rough guide for which percentage contribution levels could be explored.

TABLE 27: AVERAGE AGE FOR ACHIEVEMENT OF PERCENTAGE CONTRIBUTIONS OF HIGHER GRADE LOGS TO TOTAL STAND VOLUME

	Average age achieved (years)	Range of ages at achievement (years)	Average of differences from age @ 95% CMAI
Culmination of mean annual increment (CMAI)	143	60-250+	+30%
95% of CMAI	110	48-182	—
25% H and I grade	134	34-250+	+17%
30% H and I grade	142	36-250+	+25%
40% H and I grade	**161**	**40-250+**	**+43%**
50% H and I grade	183	46-250+	+65%
65% H, I, and J grade	**64**	**21-165**	**-44%**
75% H, I, and J grade	78	21-231	-33%
80% H, I, and J grade	89	28-250+	-24%
85% H, I, and J grade	104	30-250+	-10%

Logs of I grade and better have contributed roughly 40% of the harvest over the past 10 years. The average age at which stands achieved 40% H and I grade was 161 years. On average, the age of achievement of 40% of H and I grade logs in TIPSY was 43% higher than the achievement of 95% of CMAI (the basis for MHAs in the base case). Note that this threshold for achieving a proportion of H and I grade logs may be biased towards old stands, as a majority of the past 10 years harvest history has focused on natural stands. However, it also provides a baseline for merchantability

Logs of J grade and better (H, I and J grade) have contributed roughly 65% of the harvest over the past 10 years. The average age at which stands achieved 65% H, I, and J grades was 64 years. On average, the age of achievement of 65% of H, I, and J grade logs in TIPSY was 44% lower than the achievement of 95% of CMAI. Note that this threshold may be considered an economic target for second growth that may better represent the actual second growth harvest strategies on Haida Gwaii.

It is acknowledged that not every stand would need to produce the same target grade distribution. It would hypothetically be possible to use different grade distributions for different stand types to capitalize on the specific characteristics and growing conditions of the stand. However, the combinations for such an endeavour are infinite and the objective here is not to predict actual harvest ages, but rather to explore the possible implications of product-based and economic MHAs. In generating timber supply forecasts, average conditions are more important than stand-specific conditions; therefore, while recognizing that stand-level flexibility could be employed in practice, the proposed method provides a transparent and systematic approach to explore the issue.

Implications for sensitivity analysis

Due to time constraints on the TSR process, a pair of sensitivity analyses were run in which MHAs were first increased by 20% relative to the base case level, and then decreased by 20%. Based on the MHAs generated using TIPSY grade distributions, those average changes in MHA would occur, respectively, between 25% and 30% contribution from H and I grades, and between 80% and 85% contribution from H, I, and J grades. While these grade distribution ranges do not exactly match the historic harvested grade distributions as shown in Table 26, the ±20% MHA sensitivity analyses still provide a reasonable idea of the general magnitude of impact that could stem from either a focus on higher-quality logs or on shorter rotations, the latter of which could reflect an economic focus, which would lead to a desire to harvest a stand as soon as it contains a reasonable amount of merchantable timber.

Harvest Rules

The rules described below are common principles used by timber supply modelers throughout the province. Some of the rules have less applicability in Haida Gwaii than in other areas, however, all are provided for completeness.

For the base case harvest forecast, individual forecasts for each of the three management units (MUs) were developed that meet the following **analysis-related principles**. The individual forecasts were combined into an overall Haida Gwaii forecast.

1. **Define the upper limit on timber supply over a 400-year horizon, while respecting management constraints (including new LUOO and SLUA) and not jeopardizing long term harvest levels.** New protected areas/conservancies from the SLUA are excluded from the operating (or timber harvesting) land base while integrated resource management objectives such as fish habitat, cultural heritage, biodiversity, visual quality, and hydrological integrity, are maintained in the modeling environment through application of forest cover requirements that ensure desired forest conditions are maintained before harvesting can occur. We are trying to find out how much timber supply there is while maintaining desired values over the planning horizon, which in this case is 400 years long.
2. **Maintain a non-declining flow if possible.** Our base case forecast is non-declining from 2010 onward. However, not shown, but just to the left of our forecast chart is a single very large declining step from the current AAC of 1.77 million cubic meters. It should be noted that the downward step from *actual* harvest levels to the initial base case level, would be significantly less than from the current AAC, since actual harvests have been below the current AAC in recent years.
3. **For the purpose of sensitivity analyses, if it would assist in clarifying timber supply dynamics to develop a harvest forecast that involves declines in the short or medium term (next few decades), the decline should be no more than 10% per decade (10 x 10 rule).** For Haida Gwaii, this principle is applicable only for sensitivity analyses, and is used as a mechanism to promote understanding of timber supply dynamics, not as a recommendation on harvest flow. In principle, limiting the decline rate reflects a desire to keep any necessary change in economic activity at a gradual and controlled pace. The limit on decline rate ensures that harvest levels in the short term are not maintained at levels

that could lead to disruptions, or the need for rapid adjustments in harvest levels, further into the future.

4. **Incline by no more than 10% per decade.** While only small inclines were observed in the Haida Gwaii base case forecasts, it is still useful to speak to principles associated with inclines since they could be relevant for sensitivity analysis. Managing the rate of incline is probably not of the same socioeconomic importance as controlling rates of decline. Frequently in timber supply analysis, long-term timber supply projections are somewhat higher than short- and mid-terms levels due to the predicted effects of silvicultural management and revision of site productivity estimates. Once second-growth stands become old enough to harvest, the projected timber supply can increase quite quickly. In the case of Haida Gwaii where harvest forecasts must be developed for 3 management units simultaneously, it is reasonable to develop consistent principles to facilitate analysis in case there are significant increases from short-term to long-term timber supply in sensitivity analyses. If increasing forecasts are observed, a maximum limit on increases of 10% per decade was applied, which is the reverse of the rule applied for decreases. Application of this rule during sensitivity tests will mean that the forecasts for different management units resemble each other in shape and will not likely cross over.
5. **Avoid harvest failures.** A harvest request failure occurs when the model is unable to fulfill the harvest request and reports less harvest than requested.
6. **Reduce harvest requests sufficiently to clear pinch points.** This is the flip side of the previous point. In other words, the harvest request is set so that all shortfalls observed during higher harvest requests are barely cleared. The pinch points in the Haida Gwaii forecasts in the mid and long term.
7. **Maintain a sustainable growing stock.** This is partly ensured by the long planning horizon of 400 years, and can also be monitored by graphing the growing stock. It is unacceptable to have a growing stock that is definitely declining at the end of the planning horizon since that would signify that the LTHL is not sustainable. Growing stock that is constant on average indicates that the harvest level is sustainable.
8. **Time the increase to the long-term sustainable harvest level (LTHL) to correspond with growing stock (inventory) changes.** While evenflow forecasts were possible for the two TFLs that met all of the above principles and in which the long-term growing stock was sustainable, for the TSA such a forecast was not possible. The highest possible evenflow harvest forecast for the TSA resulted in a rising growing stock level over the long term, signifying that a higher long-term sustainable harvest could be achieved. Therefore, for the TSA an increase (of about 3%) was incorporated into the base case harvest forecast, which was timed to correspond to the time when growing stock levels began to increase in the evenflow forecast.

Harvest Priority

To define the order in which available stands in the model are harvested, an “oldest first” harvest priority rule was used. Under this rule, the oldest stands are given the highest priority for harvest.

Harvest Profile

No species profile targets were applied in the base case. However, species contributions to the base case harvest forecast were examined in a sensitivity analysis to assess the implications of maintaining the recent focus on harvest of cedar, given that harvest proportions have exceeded it's the contribution of cedar to the inventory.

Silvicultural systems

The silviculture system used in an area (i.e., clearcut, variable retention, partial cut) affects the method used for post-harvest regeneration and the expected growth and yield. For this analysis, it was assumed that all harvesting is done using a clear cut with reserves system (functionally referred to as variable retention system in the model). It is recognized that some partial harvesting has been employed on Haida Gwaii. However, the area of past partial harvesting has been limited, and no cutting permits with partial cutting have been approved in the last 5 years. District staff anticipate that the future use of high retention partial harvesting will be limited due to high costs and the fact that partial cutting promotes regeneration of hemlock and inhibits regeneration of currently more valuable cedar and spruce.

Most harvesting involves retention of some trees within blocks, which can result in shading and consequent reduction in growth rates. For the base case, no adjustments were applied to growth and yield estimates. However, prior to completion of the timber supply analysis, the JTWG will explore the RESULTS database and consult with growth and yield experts to assess if an adjustment to timber yields should be applied in a sensitivity analysis to reflect shading impacts on growth.

Timber Supply Model

The Forest Service Spatial Analysis Model (FSSAM) was used in the Timber Supply Analysis. FSSAM is a spatial, deterministic simulation forest estate model that projects harvesting and growth over a planning horizon of 400 years.

9.0 Haida Gwaii Land Use Objectives Order

Protected Area Removals

Eleven new Haida Heritage Sites/Conservancies were formally established pursuant to the Haida Gwaii Strategic Land Use Agreement of 2007, and have not been incorporated into past timber supply reviews for any of the management units on Haida Gwaii. They represent a significant land base that is no longer administered by provincial forest management agencies. These areas were identified through government-to-government negotiations between the Haida nation and the Province, initially protected under the authority of the Part 13 of the *Forest Act,* and then formally protected in October 2009 (*Protected Areas of British Columbia Amendment Act)* and October 2010 by the Haida Nation's *Haida Stewardship Law*.

The following table lists the total areas of the protected areas established pursuant to the land use agreement. All of these areas were removed when defining the timber harvesting land base (THLB).

In addition, protected areas and ecological reserves that existed prior to the land use agreement were removed from the THLB.

TABLE 28. AREAS OF PROTECTED AREA (IN HECTARES)

Conservancies	TFL58	TFL60	TSA25	TOTAL
Daawuuxusda	1,849	14,384	54,402	70,635
Damaxyaa	767	123		889
Duu Guusd	0	8	143,909	143,917
Kamdis	0	972	978	1,949
Kunxalas	647	2,650	88	3,385
Lepas Bay	0	0	2	2
Nang Xaldangaas	0	0	7,116	7,116
Nuuna Gwaay	0	1,636	197	1,833
Scaay Taaw	0	306	300	607
Tlall	0	4,378	11,933	16,311
Vladimir J Krajina	0	2,489	8,058	10,547
Yaaguun Gaandalaay	0	6,636	3	6,639
Yaaguun Suu	0	6,636	1,339	7,974
TOTAL	3,262	40,217	228,325	271,804

Riparian reserves and management zones- streams

Two classes of riparian management have been included as net downs in the model: those required under the LUOO for Type 1 and 2 fish habitat, and those required under the Forest Planning and Practices Regulation (FPPR) of the Forest and Range Practices Act (FRPA). The provisions for riparian management under the LUOO are more constraining and supersede the management provisions under the FPPR. In other words, any FPPR provision for stream riparian management classes S1 to S4 were not applied as net downs in this TSR as the provisions set out in the LUOO are more constraining. Similarly, for lake and wetlands land base exclusion based on FPPR riparian management requirements were applied only to lakes and wetlands that are *not* described as Type I or Type II fish habitat in the LUOO.

FPPR requirements for non-fish habitat

THLB removals related to FPPR requirements are associated with features that are not included as Type I or Type II fish habitat under the LUOO. All fish bearing streams (S1-S4 riparian classes) are included under the LUOO provisions. Determining where FPPR requirements should be applied required a review of the frequency of occurrence of S5 streams (large, non-fish bearing) and a definition of which lakes and wetlands are fish bearing. The latter issue is discussed in the LUOO requirements sub-section below.

While the Riparian Area Management Guidebook called for as much as 50% retention of dominant and co-dominant stems in the management zones of S5 streams, a variety of TSR net down techniques were used in previous TSRs for the various management units, as follows:

- In the analysis for TFL 47 Moresby Block (now TFL 58)[42] no buffers along S5s were removed when defining the THLB.
- TFL 39, Block 6 (now TFL 60)[43] net down 15% of a 30m buffer (equivalent to 4.5m) using a modeled approach for mapping S5s (induced >20% gradients and field verified),
- TFL 25[44] had no riparian area reductions for S5s.
- TSA 25 used an aspatial reduction for all riparian reserve and management zones, however the subsequent Haida Gwaii timber supply models (Cortex and Gowland 2004[45]) modeled S5 streams that assumed all streams >=20% gradient were S5s.

For this TSR it was determined that the FPPR management assumptions and subsequent net downs for S5s were insignificant because S5 streams are very uncommon. A review of stream linear lengths from detailed engineering stream data from cutblocks in TFL 60 showed that approximately 9% of non-fish bearing streams are S5s. Extrapolating that frequency of S5s to the entire landbase would result in a THLB reduction for S5s of only 90 hectares. Due to this relatively insignificant area, no reduction for S5s was applied.

Section 52 of the FPPR lists forest retention amounts based on basal area within a management zone. It is assumed for modeling purposes that basal area of trees is proportional to area of land; so, for example, retention of 10% of the basal area is assumed to be adequately represented by reserving 10% of the land area in a buffer from harvesting.

The following table defines reserve and management zones for lakes and wetlands (from FPPR sections 47, 51 and 52).

TABLE 29. RIPARIAN MANAGEMENT UNDER FPPR FOR WETLANDS

Riparian Class	**Riparian Management Area (metres)**	**Riparian Reserve Zone (metres)**	**Riparian Management Zone (metres)**	**RMZ Retention (*sec 52*) ratio**	***RMZ Buffer***	***Total Buffer***
W1	50	10	40	0.2	***8***	***18***
W2	30	10	20	0.2	***4***	***14***
W3	30	0	30	0.2	***6***	***6***
W4	30	0	30	0.1	***3***	***3***
W5	50	10	40	0.1	***4***	***14***
L1-B	10	10	0	0.2	***0***	***10***
L2	30	10	20	0.2	***4***	***14***
L3	30	0	30	0.2	***6***	***6***
L4	30	0	30	0.1	***3***	***3***

[42] Angus, S. 2001. Tree Farm Licence No. 47 Block 18. Moresby Block. Timber Supply Analysis Information Package. JS Jones Sandspit Ltd. Revised December, 2001
[43] Kofoed, P.J. 1999. TFL 39, MP #8 Timber Supply Analysis Information Package. October 1999
[44] Byng, D. 2003. Western Forest Products, Tree Farm Licence 25, Timber Supply Analysis Information Package. Management Plan 10. Revised.
[45] Cortex Consultant and Gowland Technologies. 2004. Haida Gwaii/Queen Charlotte Islands LUP Base Case Analysis Timber Supply Modeling Assumptions

LUOO requirements for Type I and Type II Fish Habitat

The LUOO classifies retention and subsequent net downs for fish habitat into two classes. Type I fish habitat refers to low gradient (<5%) S1, S2 and S3 streams, whereas type II fish habitat refers to any S4 stream, or higher gradient S1, S2 and S3 stream.

Net downs are based upon the Type I and Type II fish habitat as shown in *Schedule 4* of the LUOO (available at http://www.ilmb.gov.bc.ca/sites/default/files/resources/public/PDF/LRMP/haidaGwaii/HGLUOSched04_FishHab_20101125.pdf).

The TRIM map base data does not include all streams, and some unmapped streams are fish bearing. Fall et al. (2009) conducted an analysis comparing field based stream class data from TFL 60 with the Type I and II fish habitat data. They found that approximately 16% more stream length was fish bearing in the detailed engineering stream class inventory than in the mapped TRIM. Additional analysis using the detailed engineering stream class data showed, based on linear lengths, that 18% of these unmapped streams are Type I fish habitat and 82% are Type II.

In Schedule 4 of the LUOO there are 8,502 km of Type 1 fish streams and 4,658 km of Type 2 for a total of 13,161 km. Knowing that there is 16% more fish habitat overall and that 18% of it is Type 1 allows the length of unmapped Type 1 to be calculated.

Unmapped Type 1 fish bearing streams:

> 13,161 **x** 16% **x** 18% = 379 km
> Add unmapped to mapped Type 1 streams: 8,502 + 379 = 8,881 km (a 4.45% increase)

The same calculation for Type 2 streams:

> 13,161 **x** 16% **x** 82% = 1,726 km of unmapped Type 2 fish bearing streams.

Adding unmapped to mapped Type 2 fish bearing streams: 4,658 + 1,726 = 3,831 km (a 37% increase)

Since the actual location of the additional habitat is unknown, buffer widths for known fish streams were increased proportionately to account for it

According to the LUOO, a reserve zone (RZ) two tree lengths wide on either side is applied to Type 1 fish bearing streams. For Type 2 fish bearing streams the requirement is 95% of a 1 tree length RZ and 80% of a 0.5 tree length management zone (MZ). Tree lengths were determined using the LUOO *Schedule 5*, which describes tree heights based on BEC ecological site series and forest age.

Applying the buffer adjustments for unmapped streams to the LUOO stream riparian management area requirements results in the following buffers:

TYPE 1 buffers = 2 tree lengths x unmapped stream factor
= 2 tree lengths x 1.0445
= <u>2.089 tree lengths</u>

TYPE 2 buffers = tree length (0.95 RZ + 0.5 x 0.8 MZ) * unmapped stream factor
= tree length (0.95 + 0.5 x 0.8) x 1.37
= 1.8495 tree lengths

LUOO Buffers for Lakes and Wetlands

Under the LUOO, lakes and wetlands that are connected by perennial or seasonal fish bearing streams are classified as fish habitat and receive the same buffers as LUOO Schedule 4 fish bearing streams. The majority of the wetlands on northeastern Graham Island are bog complexes without the conspicuous connection of surface streams to fish habitat. However, TRIM stream data links nearly all wetlands within the Queen Charlotte Lowland ecosection, and thus overstates potential fish habitat. In order to avoid overrepresentation in the TSR analysis, wetlands and lakes must meet two conditions to be classified as fish bearing:

- they must be larger than 1 hectare, and;
- they must be connected to streams with an order greater than 1 (*i.e.* with at least one tributary).

Active Fluvial Units

Active fluvial units (AFU) are defined under the Haida Gwaii LUOO as "an active floodplain, where water flows over land in a 1 in 100 year flood event, and includes low and medium benches and the zone of an active fan where active hydrogeomorphic processes are currently evident or would likely be initiated if harvesting and/or road building were to occur." Section 12 of the LUOO outlines protection of 90% of 1.5 tree lengths from the outer edge of the active fluvial unit.

The timber supply analysis accounted for active fluvial units by:

- The areas around of Skidegate Lake and Mosquito Lake on Moresby Island were mapped to an equivalent Terrain Classification survey intensity level 'B' by Terry Lewis in 2009 during Detailed Strategic Planning. Sites were air-photo interpreted and a total of 47 sites were visited as part of a quality control ground calibration process.

- In addition to the Moresby Island AFU inventory, a review of Coastal Watershed Assessments, and hydrologic assessments[46] was completed in 2009 and useable maps compiled to identify active fans or floodplains. Mapping data for the following watersheds were incorporated into the TSR analysis:

• Awun • Baxter • Blackwater • Bonanza (east and west) • Bragg • Cedar • Central • Datlamen • Eask fork • Hangover • Hans	• Hayward • Keats • Copper • Mamin • Parsons • Shale • Stormy • Talking Bear • Deena • West fork

- Lastly, for watersheds either not covered by the T.Lewis inventory, or the watershed assessment inventories mentioned above, AFU's were defined by a floodplain layer created through the Gowgaia Institutes *Riparian Fish Forest* project[47]. For this product, site series and other Terrestrial Ecosystem Mapping attributes were used to theme major riparian floodplain features.

Tree lengths

For the purpose of timber supply analysis and net downs associated with aquatic buffers, tree lengths were sourced from the Haida Gwaii LUOO's Schedule 5 '*Tree Lengths*'. Primary decile site series were applied to each polygon that intersected with an aquatic feature (Type 1, Type 2 fish habitat and Active Fluvial Units) and correlated with a tree length (m) as sourced from schedule 5.

Cultural heritage resource deductions

Cedar Stewardship Areas

Cedar Stewardship Areas (CSAs) are outlined in *Schedule 3* of the LUOO. These areas are intended to maintain an ongoing supply of cultural cedar to the Haida. The objective allows for limited commercial harvesting within CSAs, up to 10% of the total area of CSAs over a 100 year period.

TABLE 30. CEDAR STEWARDSHIP AREA REDUCTION TO THE THLB (HECTARES)

	TFL58	TFL60	TSA25	TOTAL
Gross Area	310	12,836	12,220	25,366
% Net Down	90%	90%	90%	90%
CSA Net Removal	279	11,552	10,998	22,829

[46] Brown, A. 2009. Coastal Watershed Assessment Procedure Spatial Data Collation Project. Council of the Haida Nation, Old Massett, Haida Gwaii.
[47] Broadhead, J. 2008. The Riparian Fish Forest of Haida Gwaii. A portrait of freshwater fish distribution and riparian forest habitats. Gowgaia Institute, Queen Chalotte, Haida Gwaii.

Monumental Cedar, including Cultural Cedar Stands

Section 9 of the LUOO contains objectives for protection of monumental cedar and cultural cedar stands. This section outlines how the LUOO provisions for protecting monumental cedar and cultural cedar stands, including reserve and management zones, was accounted for in the definition of the THLB.

The LUOO defines monumental cedar as a visibly sound western redcedar or yellow-cedar tree that is greater than 100 cm in diameter at breast height with a log length of 7 m or longer above the flare with at least one face that is suitable for cultural use. Sub-section 9(3) of the LUOO focuses on protection of monumental cedar with diameter greater than 120 cm. The LUOO hence provides for some ability to harvest monumental trees outside of cultural cedar stands in the 100-120 cm diameter range, provided that the greater of 10% or 1 monumental cedar is retained within the development area. Since the LUOO contains somewhat different provisions for monumental cedar inside and outside of cultural cedar stands, area requirements for monumental trees were determined separately, as outlined below.

An estimated frequency of occurrence for monumental cedar was based on a review of Harvest Billing System (HBS) data, and depletion (i.e. areas logged) data. Harvest volumes from HBS were used in conjunction with updated harvest depletion history to determine the average volume of a given species and grade per hectare harvested. Cutting Permits with over20% of the area in partial retention blocks were not included in this assessment. HBS provided volumes harvested by grade and species for the Haida Gwaii Forest District between 1995 and 2007, as well as piece scale data for 238 cutblocks on Haida Gwaii. HBS piece scale data were used to determine the distribution of D, F and H grades of cedar by two diameter classes: greater than 120 cm and less than or equal to 120 cm.

Cedar has been a profitable species, and has largely supported harvesting on Haida Gwaii for the last 10 to 15 years. It is likely that the proportional contribution of cedar to timber harvest over this period provides an overestimate of cedar volumes, and specifically monumental cedar volumes, remaining on the timber harvesting land base.

CHN spatial analysis of 2,345 monumental cedar points indicated that 52% of monumental cedars were found in "cultural stands" as defined in the LUOO (i.e. stands with three or more culturally modified trees, monumental cedar, or a combination thereof, where each tree is within 50 meters of another tree). This analysis also found the average retention areas for monumentals in cultural cedar stands (accounting for buffer overlaps) was 0.28 monumental/ha, and that 16% of monumentals occurred within type I and II fish habitat reserves (i.e. outside of the THLB).

To determine a reduction to the THLB to represent management for monumental cedar, monumentals were classified as any D and F grade log with a butt diameter of 100 cm or more, and 20% of H grades with butt diameter over100 cm. Due to a declining trend in the volume of high-grade cedar harvested between 1995 and 2007, a logarithmic regression was run as part of the Detailed Strategic Planning analysis process to forecast the number of monumental trees per hectare in 2010, which was used to project current *and future* presence of monumentals. However, since the occurrence of monumentals is declining over time, the use of the 2010 estimate will a) overestimate cedar available for cultural use in the operating landbase; and b) overestimate the impact on the THLB due to the protection of cedar, since less cedar is likely to be found in the future. However, considering the relatively short time over which old-growth cedar is projected to be harvested (only for another 40-90 years), this method was considered a reasonable and precautionary surrogate for predicting LUOO impacts.

The MFLNRO *Tree Compiler Software System* (TREEVOL) can be used to convert a volume harvested to a number of trees based on taper equations.

TABLE 31. MONUMENTAL CEDAR AND CULTURAL CEDAR STAND REDUCTION TO THE THLB

1	Monumental trees per ha in 2010 based on logarithmic regression from HBS	0.50 trees/ha
2	Monumental trees in riparian (from CHN analysis)	16%
3	Monumental trees per ha in operating area[a] (row 1 **x** row 2)	0.42 trees/ha
4	Monumental trees in a cultural stand (from CHN analysis)	52%
5	Monumental trees in a cultural stand per ha (row 3 **x** row 4)	0.22trees/ha
6	Monumental trees >=120cm per ha (row 3 **x** proportion of monumentals[b] >=120 cm)	0.17 trees/ha
7	Monumental trees >=120 cm per ha in operating area (row 6 **x** row 2)	0.14 trees/ha
8	Monumental trees >120 cm per ha outside of a cultural stand (100% - row 4) x row 7	0.07trees/ha
9	Average retention area in ha per monumental in a cultural stand (from CHN analysis)	0.28 ha
10	Average retention area in ha per individual monumental tree[c]	1.1 ha
11	Per ha impact from cultural cedar stands (row 5 **x** row 9) (monumental trees/ha x average area retained per tree)	6.1%
12	Per ha impact from monumental >=120 cm outside of cultural stands (row 10 **x** row 8) (monumental trees/ha x average area retained per tree)	7.6%
13	**Total monumental cedar per hectare** (row 11 + row 12)	**13.7%**

Notes:

(a) Operating area is here defined as area not in riparian reserves

(b) Proportion of monumental >=120 cm diameter based on scale data from HBS

(c) Average 40-m tree height and a 1 tree length reserve and 0.5 tree-length management zone, which amounts to 11,309 m^2 or about 1.1 ha

The total percentage requirement for monumental cedar is the sum of the requirement for areas within and outside of cultural cedar stands, or 13.7%. This percentage was applied as a removal from the THLB for all stands with an age of 250 years or greater.

It is recognized that there can be “co-location” of monumental cedar with retention of old forest for other purposes. It was assumed for the analysis that retention for other purposes can meet some but not all needs for monumental cedar. Specifically, it was assumed that the contribution to monumental cedar will be in proportion to the percentage retention for other purposes. For example, if 40% of a 20 ha development area was retained for other EBM values, the reduction for monumental cedar would be 13.7% of the un-reserved portion of the development area (i.e., development area minus existing reserves in development area).

In this example, net monumental reserves = (20 ha – 8 ha) **x** 0.137 = 1.644 ha.

Culturally Modified Trees
A 1999 study[48] was conducted for the previous Timber Supply Review in the TSA looking at reserve areas in cutblocks due to culturally modified trees (CMT).

A total of 396 cutblocks harvested in the Haida Gwaii Forest District between 1995 and 1998 were reviewed for reductions due to the presence of culturally modified trees. The results showed that the average per cent cutblock area reserved from harvest exclusively due to CMTs was 6.4% (weighted average based on gross cutblock area for all licensees).

The reserve area around CMTs for that analysis was a buffer with a 50-m radius. Section 9 of the LUOO requires a 0.5 tree length reserve and 90% retention within 1 tree length management zone. Using a 40 m average tree length, this amounts to a net down buffer with a radius of 56 m. Using an area calculation, this amounts to a 20.5% area increase in relation to a 50 m buffer. A 20.5% increase to the 6.4% area reduction results in a 7.7% reduction, which was applied as an aspatial reduction in all old forest (natural stands >250 years old) to account for the protection of CMTs.

Cedar Retention
Section 7 in the LUOO specifies retention requirements for western redcedar and yellow-cedar. The order specifies that a minimum of 15% of the pre harvest composition of cedar should be retained, with a minimum of a 1 hectare retention area. The requirement applies where (a) the development areas are greater than 10 hectares and the combined western redcedar and yellow-cedar component of pre-harvest stand composition is greater than 30%; or the development areas are equal to or less than 10 hectares and the combined western redcedar and yellow-cedar component of the pre-harvest stand composition is greater than 60%. The LUOO also requires that stands where western redcedar and yellow-cedar comprise 20% or more of the area prior to harvest, the pre-harvest species composition should be retained during regeneration. This regeneration objective does not apply to the THLB definition, but is addressed in silviculture assumptions.

Given uncertainty about the block sizes to be used in timber supply modeling when determining the land base exclusion for cedar retention, a single area-weighted cedar composition threshold for application of the LUOO provision was determined based on the block sizes in RESULTS and ECAS. That review showed that very few block are less than 10 hectares in size, and therefore the weighted average threshold for application is very close to 30%. Therefore, for the analysis, the LUOO requirement for cedar retention was applied to stands where the cedar composition was 30% or greater.

The history of post-harvest cedar regeneration on Haida Gwaii is variable depending on when harvesting occurred. Prior to the mid-1990s, outside of areas near towns with significant hunting pressure, very little cedar was regenerated after harvesting, primarily due to the mortality from deer browse. From the mid-1990s onwards, a district cedar strategy required regeneration of cedar and appropriate technologies were developed and used to protect young cedar from deer browse. Hence, cedar composition of younger stands is higher than in stands regenerated 15 to

[48] BC Ministry of Forests, 2000. Queen Charlotte Timber Supply Area Analysis Report.

about 50 years ago. This variable history presents some challenges with respect to modeling the LUOO requirement that 15% of *pre-harvest* cedar composition be protected. The complication applies to second growth stands, since information is not available on pre-harvest composition of older second growth. Nevertheless, the composition of existing second growth is not a given, and therefore, RESULTS for recently harvested and regenerated, and inventory data for older second growth, and old growth, can be used as the basis for defining cedar retention requirements.

For old forest, retention to protect monumental cedar or CMTs (or any other EBM constraint) can contribute to the overall cedar retention target for a development area. Since a 21.4% net down per hectare will apply for cedar areas (combined CMTs and monumentals/cultural cedar stands) an additional net down of 15% to represent the maintenance of cedar composition would constitute double counting. Therefore the pre-harvest cedar composition net down of 15% was applied in this timber supply analysis for stands over 250 years of age.

However, an aspatial landbase reduction amounting to 15% of the pre harvest composition of cedar has been applied to the resultant output file for managed stands where the inventory or RESULTS indicates the cedar composition is over 30%.

Haida Traditional Heritage Features

Class 1 and Class 2 Haida Traditional Heritage Features are outlined in *Schedule 2* of the LUOO. During the Detailed Strategic Planning process, an analysis of CMT and Archaeological Impact Assessment (AIA) surveys was conducted for cutblocks harvested between September 1995 and March 2007. The review covered 765 blocks and found 9 Class 2 heritage features (5 midden sites, 2 trails, 1 intertidal lithic) and one possible occurrence of a Class 1 feature. Therefore, 1.2% of surveys had class 2 Haida traditional heritage features (HTHFs). Due to the minimal occurrence of Class 2 HTHFs, no removal from the THLB was applied.

With respect to class 1 HTHFs, 26 Haida village sites have been identified as Class 1 features. Under Schedule 2 of the LUOO, a 500-m buffer must be retained around each village site. Accordingly, the village sites and buffers were removed from the THLB. For the analysis it was assumed that the land base removal for village sites accounts for class 1 HTHFs, and no additional removal was made for the possible feature found in the review.

Haida Traditional Forest Features (HTFF)

Traditional forest features (identified in schedule 2 of the LUOO) for the most part are significantly rare, occur within non-forested ecosystems, grow along forest edges, or are associated with special coastal sites. Data was analyzed to determine the abundance of the Devil's club plants, the class 1 forest feature that is considered most common. Of the 851 field plots from terrestrial ecosystem mapping projects on Haida Gwaii showed Devil's club occurred in 0.9% of the plots, and in only 0.7% of plots outside of a riparian ecosystem. Other class 1 forest features are either considered nearly extirpated (high bush cranberry, black hawthorn), or grow in specialized coastal sites (fairy slipper) or estuarine environments (northern rice root). Class 1 Haida Traditional Forest Features were therefore considered to have a negligible impact on the timber harvesting land base, and therefore were not modeled.

There are provisions for flexibility in managing for class 2 forest features, as only 50% of occurrences require stand level protection. It is assumed that the majority of these occurrences can be designed to benefit from retention for other purpose, such as protection of riparian areas, cedar or wildlife habitat.

It was assumed that a 5% aspatial reduction to account for stand-level biodiversity will account for necessary protection of Class 2 traditional forest features, as well as Western yew and black bear dens, as discussed under the Stand-Level biodiversity section.

Western Yew Trees
Section 8 of the LUOO outlines objectives for Western yew. It was assumed that a 5% aspatial reduction to account for stand-level biodiversity will account for protection of western yew trees as required under Section 8 of the LUOO, as well as Haida Traditional Forest Features and black bear dens (see Stand-Level biodiversity section).

Wildlife

Black bear
Section 18 of the LUOO specifies protection of black bear dens within the Haida Gwaii District. These are features that are incidentally identified during operational planning. Inventories for these features are incomplete. It was assumed that a 5% aspatial reduction to account for stand-level biodiversity will account for protection of black bear dens, as well as Haida Traditional Forest Features and Western Yew (see Stand-Level biodiversity section).

Northern Goshawk
The Queen Charlotte Goshawk (*Accipiter gentilis laingi)* has a provincial conservation status of a red-listed species, and is listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as threatened.

The LUOO requires that Goshawk reserves identified in a schedule to the LUOO be protected, and that newly discovered nests not identified in the schedule be reported and that a protective reserve be maintained around them. The approach used for the base case was to exclude the existing reserves and to approximate the location and number of potential nest based on current research, and exclude areas corresponding to potential nest sites.

Two Wildlife Habitat Areas exist (#6-001 and #6002), each with approximately a 240-hectare post-fledgling area (100% net down), and 2,140 and 2,300 hectare foraging areas respectively. Forest seral distribution in the foraging areas is to be maintained at a minimum of 20% old and 40% mature, and a maximum of 20% young.

An additional 11 nesting reserves have been established under section 20 of the LUOO (*Schedule 12)*.

The average nesting reserve size is 225 hectares and was a 100% net down in the timber supply analysis.

Additional 24 nesting reserves (200 ha each) were netted down based upon potentially viable territories (see Appendix 2).

TABLE 32. REDUCTIONS TO THE THLB (IN HECTARES) TO ACCOUNT FOR NORTHERN GOSHAWKS

Species	Nest Area Name	TFL58	TFL60	TSA25	TOTAL
Goshawk	Ain	0	0	199	199
Goshawk	Blackbear	0	40	405	445
Goshawk	Crease	0	199	0	199
Goshawk	Demon	0	257	0	257
Goshawk	Flo	0	208	0	208
Goshawk	Hancock	0	0	200	200
Goshawk	Ian_315	0	197	0	197
Goshawk	Ian_990	0	0	399	399
Goshawk	Lignite	0	0	201	201
Goshawk	Skowkona	0	9	190	199
Goshawk	Three Mile	0	94	105	199
Goshawk	Potential Nest sites	451	2135	2215	4800
Goshawk	TOTAL	0	1004	1699	2,703

Northern Saw whet owl (SAWO)

The Northern Saw-whet owl, *brooksi* subspecies (*Aegolius acadicus brooksi)* is a provincially blue-listed species, and federally listed as threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Accounts and Measures for managing Saw whet-owl are listed in the Identified Wildlife Management Strategy[49]; however no formal Wildlife Habitat Areas have been established on Haida Gwaii.

There are 11 Saw-whet owl nesting reserves, established under section 22 of the LUO (*schedule 12)*. The average size of the nesting reserves is 67 hectares. All reserves were excluded from the THLB (100% net down).

The LUOO has similar provisions for nests discovered in the future as for Nothern Goshawk. Specifically, section 22.2 speaks to reserving 10 hectares around nests not found in Schedule 12. However, no SAWO nests have been found on Haida Gwaii (only general territories). At this time, Schedule 12 represents the best available information put forward by the SAWO Recovery Team for known territories. In addition to the low probability of finding nest areas, the 10 ha requirement is small enough that this objective seems to have inconsequential effects to timber supply (i.e., would affect a small proportion of the land base). The LUOO requires SAWO territory interspacing

[49] British Columbia Ministry of Water, Land and Air Protection. 2004. Accounts and Measures for Managing Identified Wildlife. Version 2004. Biodiversity Branch, Identified Wildlife Management Strategy, Victoria, B.C.

distances of 1400m to be retained where practicable, however no size threshold is given (only 'stand level retention'), therefore it is believed that other EBM retention will meet this objective.

TABLE 33. REDUCTIONS TO THE THLB (IN HECTARES) TO ACCOUNT FOR SAW WHET OWL NESTING RESERVES

Species	Nest Area Name	TFL58	TFL60	TSA25	TOTAL
Saw-whet Owl	SWO05	0	0	59	59
Saw-whet Owl	SWO07	0	85	0	85
Saw-whet Owl	SWO08	0	70	0	70
Saw-whet Owl	SWO09	0	44	0	44
Saw-whet Owl	SWO10	0	71	0	71
Saw-whet Owl	SWO11	0	39	0	39
Saw-whet Owl	SWO13	0	60	0	60
Saw-whet Owl	SWO14	0	11	0	11
Saw-whet Owl	SWO16	0	78	0	78
Saw-whet Owl	SWO18	0	112	0	112
Saw-whet Owl	SWO21	0	0	100	100
Saw-whet Owl	TOTAL	0	571	159	730

Marbled Murrelet

The Marbled murrelet (*Brachyramphus marmoratus)* is a provincially blue-listed species, and federally listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Two formal Wildlife Habitat Areas have been established in the Eden Lake landscape unit (#6-041, 6-046) that are 177 and 90 hectares respectively. Each of these areas was removed from the timber harvesting land base for timber supply analysis purposes.

Prior to January 5th, 2011, an Order under section 7(2) of the Forest Planning and Practices Regulations provided protection for marbled murrelet habitat. This order was repealed and replaced under section 19 of the Haida Gwaii LUOO.

Section 19 of the LUOO provides habitat retention targets for marbled murrelet, listed in *Schedule 9*. The majority of these nesting habitat targets are met incidentally through other non-harvest areas, such as parks, cedar stewardship areas, other wildlife nesting reserves and habitat areas, or type I or II fish habitat. Any deficits to these landscape unit targets are specifically addressed through the areas reserved under *Schedule 8* 'forest reserves' of the LUOO. These forest reserves are considered to be 100% net downs for the timber supply analysis.

Great Blue Heron

The Great blue heron, *fannini* subsepcies (*Ardea herodias fannini)* is a provincially listed blue-listed species and listed as Special Concern[50] by the federal Committee on the Status of Endangered

[50] COSEWIC. 2008. COSEWIC assessment and update status report on the Great Blue Heron *fannini* subspecies *Ardea herodias fannini* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 39 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Wildlife in Canada (COSEWIC). Provisions under section 21 of the LUOO stipulate zones with a minimum of 45 hectares around active Great blue heron nest sites. While there have been as many as 24 known nest sites recorded on Haida Gwaii[51], none have been confirmed to be active within the last 3 years. A cross reference with the most recent survey report[52] identified 8 nest sites with potential activity. These 8 sites were net-down from the THLB for timber supply purposes as a pre-cautionary approach to management.

Biodiversity

Landscape level biodiversity
Section 16 of the LUOO outlines the objective to maintain old forest representation at the bioregional scale. The majority of common and rare site series targets, listed in Schedule 10, are currently met either incidentally through protected areas or 'fixed EBM reserves[53]' or by design (*i.e.* co-location) through the Schedule 8 forest reserves. However, there are also some site series where the bioregional targets are currently in deficit. Table 34 shows the portion of the bioregional conservation targets for site series that needs to be contributed from the THLB.

In the TSR model the site series were spatially identified using ecosystem mapping's primary deciles. A forest cover requirement was established based on the bioregional targets by landscape unit. The contribution from protected areas, 'fixed EBM reserves' and forest reserves were accounted for and non-THLB forested areas contributed to meeting the requirements. As the non-THLB hectares will not be harvested it is assumed that these areas, if not currently mature or old forest, can be naturally recruited over time, and as such contribute to the conservation targets regardless of their current age. Therefore the non-THLB fully contributes towards bioregional conservation targets.

[51]Dyment, P., 2006. Great Blue Heron (*Ardea Herodias fannini)* Foraging and Nesting Habitat Inventories on Graham Island, Haida Gwaii. Report prepared for the Environmental Stewardship division of the BC Ministry of Environment.
[52] Ibid.
[53] Conservancies, Parks, Ecological Reserves, Northern Goshawk nest areas, Saw When Owl nest areas, Wildlife Habitat Areas, Cedar Stewardship Areas, Type 1 and 2 Fish Habitat.

TABLE 34. SITE SERIES SUBJECT TO FOREST COVER CONSTRAINTS IN THE THLB

BEC	Site series number	Description	Forest cover constraints in THLB (hectares)
CWHwh1	16	Ss - Sword fern	-53
CWHwh1	02	CwSs - Salal	-282
CWHwh1	11	PlYc - Sphagnum	-521
CWHwh2	05	CwYc - Goldthread	-552
CWHwh2	02	CwHw - Salal	-739
MHwh	07	YcHm - Hellebore	-1
MHwh	02	HmYc - Mountain-heather	-458
MHwh	09	YcHm-Skunk cabbage	-1
MHwh	01	HmSs - Blueberry	-639
CWHvh2	11	CwYc - Goldthread	-104
CWHvh2	2	PlYc - Rhacomitrium	-3

Forested swamps

Forested swamps are made up of the ecological community Cedar-Spruce-Skunk cabbage, otherwise known as site series 12 (CWHwh1), 06 (CWHwh2) and 13 (CWHvh2). Ecosystem mapping coverage for Haida Gwaii was used to identify the leading site series. The following table shows the total area of forested swamps by management unit, and the area that was removed from the THLB due solely to the occurrence of forested swamps.

TABLE 35. LAND BASE REMOVALS FOR FORESTED SWAMPS.

	TFL58	TFL60	TSA25	TOTAL
Total area (ha)	433	206	13,639	14,278
Net removal according to net-down sequence (ha)	245	18	399	663

Red and Blue listed ecological communities

Section 17 of the LUOO identifies constraints on harvesting of red and blue listed ecological communities. The Schedule 13 list of red and blue listed communities was used to spatially identify leading site series for the timber supply analysis.

Blue-listed ecological communities were accounted for through a forest cover constraint on the THLB. The constraint was a 30% allowable harvest within Blue-listed ecological community units, a reflection of Section 17 LUOO allowances.

The following table shows the total area of red-listed ecological communities by management unit, and is the area removed from the THLB due solely to the occurrence of these ecological communities. Based on the sequential nature of the reduction, a significantly smaller area than the total was excluded solely to account for red-listed communities.

TABLE 36. LAND BASE REMOVALS FOR RED-LISTED ECOLOGICAL COMMUNITIES.

Red Listed Site Series	TFL58	TFL60	TSA25	TOTAL
Total area (ha)	3	2,577	9,828	12,408
Net removal in the netdown sequence due to overlaps with other categories (ha)	0	134	1,667	1,801

Stand-Level biodiversity

The Forest Planning and Practices Regulation outlines a general objective for wildlife and biodiversity at the stand level. Stand-level biodiversity is not an explicit objective set in the SLUA or LUOO. It is anticipated that stand level biodiversity requirements will be met by the suite of other EBM value reserves such as riparian management areas, cedar stewardship, rare ecosystem management and wildlife retention areas. Similarly, it is also anticipated that the FPPR Section 66 requirement for Wildlife Tree Retention will be met incidentally through other retention set out to meet EBM objectives and therefore is not specifically modeled in this TSR.

Due to a lack of inventory information, some objectives in the LUOO (Class 2 Haida heritage forest features, Western yew patches and Bear dens) will not be accounted for by specific land base reductions or forest cover requirements. However, a 5% general stand-level net down was made in this TSR to account for these objectives. As outlined in the section on monumental cedar, it was assumed that land base removals for other purposes contribute in part to the 5% stand-level biodiversity requirement. The 5% reduction was applied assuming that the retention is equally distributed throughout a harvest unit (a 'random distribution assumption'). For example if 40% of a development area is made up of EBM reserves, then only 3% of the 'harvestable' portion of the development area would be netted down for this general stand level provision. Two percent (or 40% of 5%) would be attributed to the existing reserves in the development area.

Hydrologic Recovery

Both the LUOO's sensitive watershed objectives and upland stream objectives require a certain condition of hydrologic recovery in order to maintain the quality and quantity of water within the natural range of variation. Post-disturbance watershed response, or hydrologic recovery, is normally associated with tree height[54]. The degree of recovery increases as the tree height in a stand increases.

Research on hydrologic recovery on the coast is evolving. The JTWG worked with a hydrologist from the MFLNRO Coast Region to determine the state of knowledge regarding hydrological recovery, and to build sensitivity analyses to assess the implications of the most up-to-date knowledge.

The SLUA, DSP, and timber opportunity analyses employed the Coastal Watershed Assessment Procedure (CWAP) hydrologic recovery curve (See Figure 21). The CWAP recovery curve is based upon studies of watersheds where spring snowmelt in the absence of rain is the primary driver of peak flows.

However, most peak flow events on Haida Gwaii are rain on snow events. In this area, forest harvesting has the effect of increasing both snow depths and the energy available to melt that snow. Therefore, hydrologic recovery curves designed to represent rain on snow (ROS) dynamics should be used if available.

Relevant data exist for ROS hydrologic recovery from regenerating stands from the Russell Creek Experimental Watershed on Vancouver Island[55]. Results of that research by the MFLNR hydrologist suggest that ROS recovery rates in that watershed are approximated by the snow-on-snow (SOS) recovery curve in Figure 21[56]. Since it is a reasonable approximation, he recommends using the SOS curve shown in Figure 21 to represent the ROS dynamics that dominate peak flow events on Haida Gwaii. It is assumed to be appropriate to apply that regime to all watersheds on Haida Gwaii regardless of elevation.

Figure 21 shows the CWAP, ROS and SOS curves mentioned above and a curve for rain dominated areas. The Russell Creek research findings are not currently finalized.

---

[54] Hudson, R. G.Horel. 2007. An operational method of assessing hydrologic recovery for Vancouver Island and south coastal BC. Forest Research Brach Technical Report 032. Nanaimo, BC.

[55] William Floyd, Research Hydrologist, Ministry of Forests, Lands and Natural Resource Operations.

[56] Recovery curve sourced from David Campbell, reviewed by William Floyd (MFLNR). This recovery curve was originally for Snow on Snow precipitation regimes, however resembles unpublished hydrologic recovery research findings from the Russell Creek experimental watershed on Vancouver Island for the Rain on Snow precipitation regime.

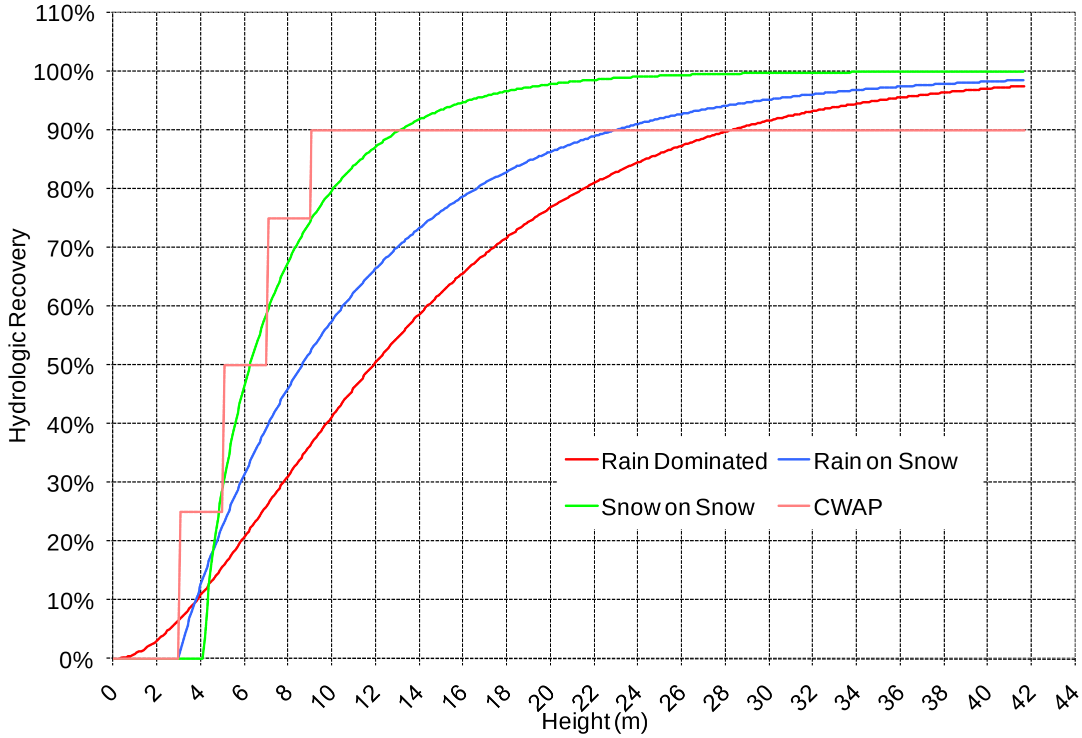


FIGURE 21. HYDROLOGIC RECOVERY CURVES [57]

Requirements for Sensitive Watersheds and Upland Streams

In the TSR modeling environment maintaining a state of hydrologic recovery in upland streams sub-basins and sensitive watersheds sufficient to comply with the LUOO is required. Section 14 of the LUOO identifies a rate of cut for the sensitive watersheds identified in Schedule 7 of the LUOO. The objective stipulates that no harvesting may occur in sensitive watersheds with an equivalent clearcut area (ECA) that is equal to or greater than 20%. That is, at least 80% of a watershed must be considered hydrologically recovered for additional harvesting to be permitted.

The LUOO also stipulates that an average maximum of 1% of a given watershed may be harvested annually (although the period over which harvesting may be averaged varies by watershed size). Watershed area is gross area, not just forested area, because the entire drainage basin forms the hydrological response to water inputs[58].

[57] Recovery curve sourced from David Campbell, reviewed by William Floyd (MFLNR). This recovery curve was originally for Snow on Snow precipitation regimes, however resembles unpublished hydrologic recovery research findings from the Russell Creek experimental watershed on Vancouver Island for the Rain on Snow precipitation regime.

[58] Church, M, B. Eaton. 2001. Hydrological Effects of Forest Harvest in the Pacific Northwest. Technical Report #3. Department of Geography, The University of British Columbia, Vancouver, B.C.

Section 13 of the LUOO states that 70% of the forest in an upland streams area listed in Schedule 6 must be maintained as hydrologically recovered. Hydrologic recovery levels, as represented by tree heights follow the same recovery assumptions as applied for sensitive watersheds.

Base Case Watershed Constraints

Watershed constraints were set such that no more than 20% of each sensitive watershed (and no more than 30% of the upland stream area in each upland stream sub-basin) could be shorter than a specified height (converted to area weighted average age). This calculation was made for each upland stream sub-basin and each sensitive watershed containing some THLB. (See Table 37 below). The height specified for the base case was 9m, and reasons for the use of that height is explained in the following paragraphs.

The SOS curve in Figure 21 is recommended for use in the base case as reasonably resembling a Rain on Snow curve to which 90% recovery is reached at a 14m stand height. However, the timber supply model used in the analysis (FSSAM) does not directly utilize continuous hydrological recovery curves. FSSAM constraints are simply set to allow a certain percent of area within a constraint assessment area to be younger than a specific age. When using a 14m cut-off (either contributing to recovery or not contributing to recovery), contributions of partial recovery from shorter stands are not accounted for.

To assess the implication of this, the current state of hydrologic recovery was assessed for 357 watersheds within the operating land base of Haida Gwaii; once using a recovery curve that accounted for the partial recovery from shorter stands, and once defining recovery with stands only taller than 14m. There was between 6%-8% more area recovered when acknowledging the contributions from stands of all heights.

As the timber supply model can only account for an assessment area to be either younger or older than a specific height (age), it was necessary to determine how much to lower the height to account for this 6%-8% more area recovered. Through analysis it was confirmed that the base case be lowered to 9m from the 14m cut-off to reasonably account for these contributions from shorter stands. The approximate average age of stands reaching 9m is 30 years old. Therefore, in general terms, 80% of stands within sensitive watersheds, and 70% of stands within upland stream areas needed to be on average >=30 years old before harvesting could occur in those units.

In addition to adjusting the constraint requirements to better represent the intent of the LUOO and the best available science, modeling outcomes will be evaluated using the method described above (i.e., how much area is hydrologically recovered based on the recovery curve) to ensure that this adjustment does not allow non-compliance with LUOO hydrologic green-up requirements.

Sensitivity analyses

A series of sensitivity analyses are being conducted in order to test the associated impacts on harvest forecasts:

1. *14-metre hydrologic recovery:* 14 metre regenerated tree height (90% recovered), regardless of precipitation regime, was used for a sensitivity analysis. This did not account for any partial recovery contributions from stands shorter than 14m.

2. *7-m hydrologic recovery:* This measure was used in the 2009 DSP timber supply analysis[59] and the 2007 timber opportunity analysis[60] and is considered a useful comparative benchmark for this analysis.

3. *18m hydrologic recovery:* The 14-m 'rain on snow' recovery curve uses the statistical argument that hypothesizes that recovery can be measured using the mean of peak flows. However, some researchers are currently debating that recovery should account for the *variability* of stream flow (i.e. return intervals of specific peak flow events) which may not return to pre-harvest levels until stands are taller/older than for mean events. To account for this, a rain on snow curve using an 18-m recovery threshold was used based upon the recommendation of the MFLNRO regional hydrologist William Floyd. This explores the outcomes of what happens if watersheds can't recover from the greatest ranges in flow events until stands are taller than what was assumed in the base case. This new curve (Figure 22) is based on the equation: $HR=100*(e^{-0.108(H-4.5)})^{1.52}$. Where *HR= Hydrologic Recovery (*between 0 and 100; *H*= Height of stand in metres).

   The curve was provided by W. Floyd and is based on adjustments from Hudson and Horel (2007)[61] results using the Chapman-Richards equation and curve fitting parameters to derive the equation presented above.

   Since the timber supply model uses binary forest cover requirements (i.e., a stand either meets hydrological recovery or it does not), the strategy for this sensitivity analysis will be to test the base case outputs to check on the levels of recovery in each watershed based on the hydrological recovery curve discussed here

[59] Fall, A. J. Sunde, N. Reynolds. 2009. Haida Gwaii Detailed Strategic Planning Decision-Support. Analysis of the 2009 Strategic Land-Use Objectives.

[60] BC Ministry of Forests and Range. August 2007. Timber Harvesting Opportunities Arising from the Implementation of the Proposed Land Use Zones and EBM Provisions - Haida Gwaii Strategic Land Use Agreement of May 29, 2007

[61] Hudson, R. G. Horel. 2007. An operational method of assessing hydrologic recovery for Vancouver Island and south coastal BC. Forest Reseach Technical Report 032. Coast Forest Region, Nanaimo, B.C.

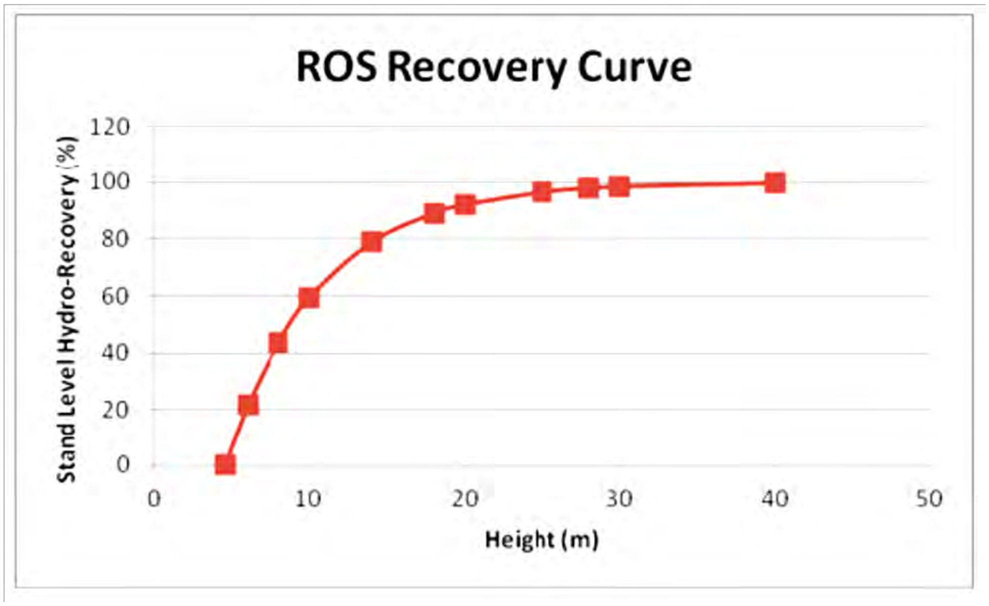


FIGURE 22. RAIN ON SNOW RECOVERY CURVE AT 18M

TABLE 37. AREA-WEIGHTED AVERAGE AGES TO MEET HYDROLOGIC RECOVERY HEIGHTS FOR SENSITIVE WATERSHEDS.

Watersheds	Age for Area Weighted Average 7m age	Age for Area Weighted Average 9m age	Age for Area Weighted Average 14m age
Non Sensitive Watersheds	26	31	46
Ain River	24	28	40
Awun River	24	29	41
Blackwater Creek	24	29	41
Bonanza Creek	23	28	39
Brent Creek	23	26	37
Canyon Creek	23	27	38
Chinukundl Creek	28	34	52
Copper Creek	22	26	36
Davidson Creek	25	29	42
Deena Creek	23	27	38
Florence Creek	23	27	38
Ghost Creek	24	28	40
Gold Creek	23	26	37
Haans Creek	23	27	38
Honna River	24	28	40
King Creek	23	27	39
Lagins Creek	25	30	44
Lagoon Creek	20	23	31

Watersheds	Age for Area Weighted Average 7m age	Age for Area Weighted Average 9m age	Age for Area Weighted Average 14m age
Lower Yakoun River	24	28	40
Mamin River	24	28	40
Mathers Creek	25	30	44
Naden River	25	29	42
Pallant Creek	21	25	34
Phantom Creek	25	29	42
Queen Charlotte Comm. Wsh	22	26	37
Riley Creek	22	26	37
Sachs Creek	23	27	38
Skedans Creek	23	27	39
Slarkedus Creek	25	30	44
Tarundl Creek	24	28	40
Upper Yakoun River	22	26	36

10.0 Sensitivity Analyses

TABLE 38. PLANNED SENSITIVITY ANALYSES.

Theme (base case)	Description of parameter change relative to base case
Site productivity (base: Stump SI for Hw and Ss >140 yrs, SIBEC w/ existing eco-system mapping; RESULTS where available)	(1) Site Tools (site index derived from forest inventory species, age and height information via TIPSY/VDYP). Applies to areas covered by ecosystem mapping within the base case.
	(2) SIA study from TSA (Ss/Hw stands 16-80 yrs).
Hydrological recovery (9-m height in upland sub-basins and sensitive w/s used in base case)	(3) Recovery heights of 14 metres in upland sub-basins (30%) and sensitive watersheds (20%) (4) Recovery heights of 7 metres in upland sub-basins (30%) and sensitive watersheds (20%) (5) Recovery heights of 14 metres in upland sub-basins (30%) and sensitive watersheds (20%)
Minimum harvestable age (age @ 95% CMAI for preliminary base)	(6) ±20% from base case levels (7) Use of grade percentages for exploring harvestable ages with product and economic focuses.
Land Use Objectives Order Default Order requirements	(8) Risk-managed targets (reduction to riparian buffers, reductions to hydrological recovery targets, reduction to cultural heritage targets).
Economic operability (base case: stand volume threshold based on 99th percentile from ECAS)	(9) Volume thresholds at 90th percentile
Terrain stability (base case: 25% class IV and 50% class V excluded)	(10) Class IV 20% netdown, Class V 90% net down
Volume study (taper and loss adjustments)	(11) Determine impact on existing inventory of applying adjustment factors from the taper and loss study
Species preference for harvests	(12) Determine timber supply implications of maintaining cedar contribution to harvests at same proportion as over past 15 years
Harvest rules (oldest first in base case)	(13) Relative oldest first (14) Higher cedar proportions –based on empirical HBS trends
One unit *v.* Separate units (base: each unit with a "flowed" forecast –separate units)	(15) Generate a flowed run for the entire islands with individual units not flowed

11.0 Glossary of Terms

ECAS: the Electronic Commerce Appraisal System. This is the program whereby licensees submit detailed planning information pertaining cutblocks. This includes reports such as cruise appraisals, silviculture prescriptions etc.

HBS: Harvest Billings System (web)

JTWG: Joint Technical Working Group. This is a technical group made up of Haida Nation and Provincial staff, responsible for the timber supply analysis and associated reports.

LUOO: Haida Gwaii Land Use Objectives Order (web)

MFLNRO: Ministry of Forests, Lands, and Natural Resource Operations

MSYT: Managed Stand Yield Tables. These are growth and yield tables assigned to stand types (Analysis Units) for managed, or post-harvest, stands.

MVI: Mean Value Index. This is an analytical method that accounts for timber harveting operating costs in relation to stand values in order to define areas of economic operability.

NC: Non-contributing. This refers to areas that are outside of the timber harvesting land base

NTA: No Typing Available. This refers to areas in the forest inventory that does not contain any information.

RESULTS: RESULTS is the program where licensees submit Cut Permit and road permit level development and silvicultural spatial inventory data.

SLUA: Haida Gwaii Strategic Land Use Agreement

Site Tools:

THLB: Timber Harvesting Land Base. The area where timber harvesting is allowed and considered economically viable.

TIPSY: Table Interpolation Program for Stand Yields. This is a growth and yield model that utilizes attributes from forest inventory data to assign site productivity values for managed (second growth) stands.

TFL: Tree Farm License

VDYP7: Variable Density Yield Prediction, version 7. This is a growth and yield model that utilizes attributes from forest inventory data to assign site productivity values for natural (old) stands.

VQO: Visual Quality Objectives

12.0 Appendices

Appendix 1. Site Index by Site Series

Site Index-Site Series By Region - SIBEC RDM Version: May2008

Vancouver CWHwh1

Site Series(*)	Name	Cw #	Cw SI	Cw SE	Hw #	Hw SI	Hw SE	Ss #	Ss SI	Ss SE	Pl #	Pl SI	Pl SE	Yc #	Yc SI	Yc SE
01	HwSs - Lanky moss	15	21.4	0.6	11	22.9	0.9	36	29.2	1.1						
02	CwSs - Salal		20.0		7	23.9	1.1	11	27.9	1.8		20.0				
03	CwSs - Sword fern		20.0		8	26.9	0.9	31	29.7	0.9						
04	CwHw - Salal		16.0			24.0			24.0							
05	CwSs - Foamflower		20.0			28.0		32	35.4	0.6						
06	CwSs - Conocephalum		20.0			20.0		11	28.5	2.2						
07	Ss - Lily-of-the-valley		20.0			28.0			36.0							
08	Ss - Trisetum		12.0						32.0							
10	CwYc - Goldthread		12.0			16.0		8	31.6	2.0		16.0			16.0	
11	PlYc - Sphagnum		8.0									12.0			8.0	
12	CwSs - Skunk cabbage		12.0			16.0						16.0				
13	Ss - Salal		8.0			12.0			16.0			12.0				
14	Ss - Kindbergia		16.0			20.0			24.0							
15	Ss - Reedgrass		16.0			20.0			24.0			20.0				
16	Ss - Sword fern		20.0			28.0			36.0							
17	Ss - Slough sedge								36.0							

Appendix 2. Northern Goshawk nesting site land base reductions

Both known and potential goshawk nesting sites were excluded from the THLB in this TSR. The objective was to spatially define all current and future net downs for Northern Goshawk nest reserves within the operating landbase of Haida Gwaii. Known nest sites came from the nesting reserve layer sourced from Schedule 12 of the Land Use Objectives Order. Potential Goshawk nesting sites were determined by using the following assumptions and data sources:

1. Northern Goshawk territories were considered potentially viable by using a foraging habitat model data developed by *Cortex Consultants Inc.* for the Northern Goshawk Recovery Team and Habitat Recovery Implementation Group. The *Foraging Habitat Suitability Index* for the current conditions (*ccfhsi)* file was used and grouped into suitability classes (Nil=0-25, Low=26-50, Med=51-75, High=76-100)[62].

2. Territories were defined by known Goshawk territories (geographically centering territories to single points from multiple alternate nests). Potential territories were developed using center points from 2004 Land Use Planning circular territory models[63] (excluding new known territories that were identified since 2004). Territory circles were based upon a 10.8 km territory radius[64].

3. Thresholds for viable territories were defined by territories with >=40% medium-highly suitable foraging habitat. Note that this was not an analysis that considered temporal scales, rather only current conditions that may be relevant for a 5-10 year projection for TSR purposes. Note that while territory boundaries differed between the 2004 analysis and the subsequent 2008 Northern Goshawk Habitat Recovery Implementation Group (RIG) analysis, it is noted in the latter modeling methodology and implementation report (Smith and Sutherland 2008) that the 'circular' territories produced a similar number of territories as the RIG model when parameterized for the medium habitat threshold under the current conditions scenario.

4. Net downs for known Goshawks were based on the Schedule 12 (LUOO) nesting reserves, while net downs for potential nest sites were based on 200ha (798m radius) circles centered in the potential territories.

The analysis only considered territories within the operating landbase. Table 19 AND 20 outline the viable territory thresholds for known and potential Goshawk territories.

---

[62] Smith. J.R. G.Sutherland. 2008. Northern Goshawk (*Accipiter gentilis laingi)* Habitat and Territory Models. Report prepared for the Northern Goshawk Habitat Recovery Implementation Group. Cortex Consultants Inc.

[63] Holt, R. 2005. Environmental Conditions Report for the Haida Gwaii/QCI Land Use Plan. Veridian Ecological Consulting Ltd.

[64] Northern Goshawk *Accipiter gentilis laingi* Recovery Team. 2008. Recovery strategy for the Northern Goshawk, *laingi* subspecies (*Accipiter gentilis laingi*) in British Columbia. Prepared for the B.C. Ministry of Environment, Victoria, BC. 56 pp.

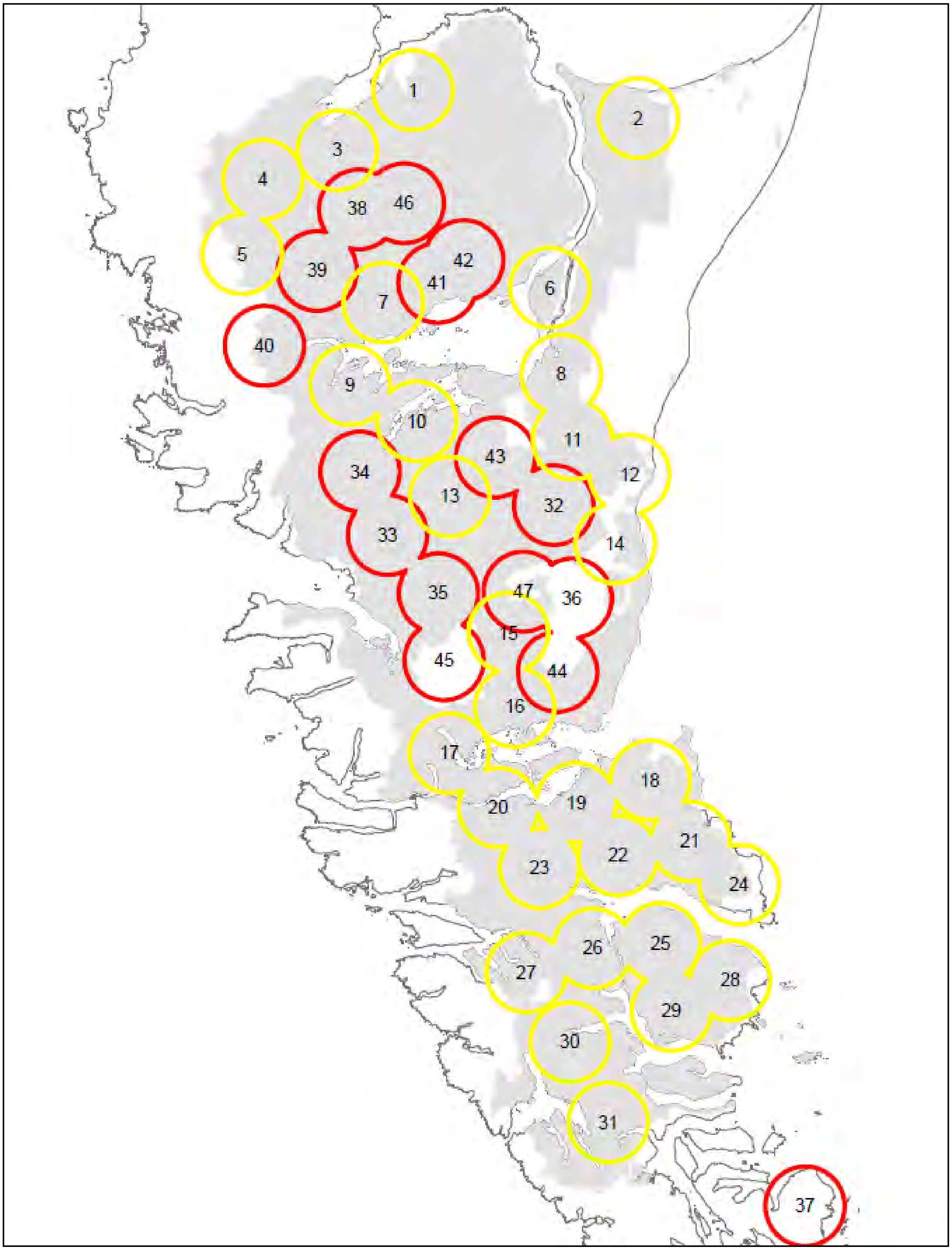
TABLE A-1. VIABLE TERRITORY THRESHOLDS FOR KNOWN GOSHAWK TERRITORIES

Territory number	Percent med to high habitat
32	69%
33	57%
34	61%
35	50%
36	79%
37	48%
38	66%
39	65%
40	41%
41	58%
42	81%
43	41%
44	67%
45	63%
46	68%
47	59%

TABLE A-2. VIABLE TERRITORY THRESHOLDS FOR POTENTIAL GOSHAWK TERRITORIES

Territory number	Percent med to high habitat	**Territory number**	Percent med to high habitat
9	32%	11	56%
15	33%	12	62%
16	33%	13	47%
24	27%	14	69%
27	26%	17	43%
30	32%	18	41%
31	38%	19	43%
1	78%	20	45%
2	47%	21	48%
3	58%	22	68%
4	48%	23	57%
5	50%	25	53%
6	47%	26	59%
7	41%	28	46%
8	48%	29	43%
10	44%		

FIGURE A-1 MAP. KNOWN (RED) AND POTENTIALLY VIABLE (YELLOW) NORTHERN GOSHAWK NESTING TERRITORIES.



Appendix 3. Data sources

Common Name	Source	Finalized Layer
Ownership	WHSE_FOREST_VEGATATION_F_OWN	HG_OWN_KG
woodsheds	e00 qci_woodshe_1 polygons	HG_WOODSHEDS
Non Forested	Cortex_HG/AnalysisData/CIT_EGSA_QCI.shp/NF_DESC	NF
Non Productive	Cortex_HG/AnalysisData/CIT_EGSA_QCI.shp/NP_DESC	NP
Visual Landscape Inventory	WHSE_FOREST_VEGETATION.REC_VISUAL_LANDSCAPE_INVENTORY	HG_VLI
Management Units		HG_MUs
Management Units	TAKEBACK_PARCELS	HG_MUs_TB
Extent	WHSE_BASEMAPPING.FWA_WATERSHEDS_POLY	HG_EXTENT
wetlands	WHSE_BASEMAPPING.FWA_WETLANDS_POLY	HG_FWA
lakes	WHSE_BASEMAPPING.FWA_LAKES_POLY	HG_FWA
river polygons	WHSE_BASEMAPPING.FWA_RIVERS_POLY	HG_FWA
Landscape Units	WHSE_LAND_USE_PLANNING.RMP_LANDSCAPE_UNIT_SP	HG_LU
Type 1 and Type 2 Fish Habitat	Land Use Objective Order	RFF_BUFF
Terrestrial Ecosystem Mapping	TEM_jul5_10_v1.shp Nick Reynolds	HG_TEM
TFL 25 block 6 forest inventory	t25_6_vri from John Sunde	HGVEG2010
TFL 39 block 6 forest inventory	t239_6_fc_polygon from John Sunde	HGVEG2010
TFL 47 forest inventory	FCINVNEW_DSLV	HGVEG2010
TSA 25 VRI	QCI_VRI	HGVEG2010

Common Name	Source	Finalized Layer
Harvest Depletions	WHSE_FOREST_VEGETATION.RSLT_OPENING_POLY	HG_RSLT_COMP
Harvest Depletions	WHSE_FOREST_VEGETATION.RSLT_FOREST_COVER_POLY	HG_RSLT_COMP
Remotely sensed recent harvests	QCI_01_05	HG_REMOTE_CUT
Remotely sensed recent harvests	QCI_05_06	HG_REMOTE_CUT
Remotely sensed recent harvests	QCI_06_08	HG_REMOTE_CUT
Remotely sensed recent harvests	QCI_08_09	HG_REMOTE_CUT
Remotely sensed recent harvests	TFL_missed	HG_REMOTE_CUT
Cedar Stewardship Areas	Land Use Objective Order	SCH03_CSA
Watershed Units	Land Use Objective Order	SCH05_WS_UNITS
Upland Stream Area watershed sub-units	Land Use Objective Order	SCH06_UpStrmSubs
Sensitive Watersheds	Land Use Objective Order	SCH07_SensWS
Forest Reserves	Land Use Objective Order	SCH08_FR
Marbled Murrelet Nesting Habitat Targets	Land Use Objective Order	SCH11_MAMU
Queen Charlotte Goshawk Reserves	Land Use Objective Order	SCH12_WHA
Saw-whet Owl Reserves	Land Use Objective Order	SCH12_SAWHET
Roads	LUOO: DSP_roads_ftenrsl_qciftrn.shp	HG_LUOO
Red Listed	LUOO: red_listed_ecosystems.shp	HG_LUOO

Common Name	Source	Finalized Layer
Ecosystems		
Villages	LUOO: h_villages_090814.shp	HG_LUOO
Forested Swamps	LUOO: for_swamp_090814.shp	HG_LUOO
Blue Listed Ecosystems	LUOO: blue_listed_ecosystems.shp	HG_LUOO
Active Fluvial Units	LUOO: afu_090814.shp	HG_LUOO
TFL 25 blick 6 operability	operability.shp	HG_OPER
TFL 39 block 6 operability	oper	HG_OPER
TFL 47 operability	t47_18_res	HG_OPER
TSA 25 operability	Harv_sys4	HG_OPER
Community Watersheds	WHSE_WATER_MANAGEMENT.WLS_COMMUNITY_WS_PUB_SVW	HG_COM_WS
Biogeoclimatic Ecosystem Classification	WHSE_FOREST_VEGETATION.BEC_BIOGEOCLIMATIC_POLY	HG_BEC
Recreation Sites	WHSE_FOREST_TENURE.FTEN_RECREATION_POLY_SVW	HG_REC_POLY
Log Dumps	Coast Appraisal Manual - Appendix VI	HG_LogDumps
River, Lake, and Wetland Buffers	HG_FWA & Riparian Management Area Guidebook	HG_FWA_RMAs
TEM Adjustments	ECORA	QCI_ECP
Terrain Stability	hg_terrain	HG_TERRAIN
Potential Blue Heron	blhe_pot_nest_sites_albers	pot_blu_her
Potential No Go	nogo_pot_via_terr_apr15_11	pot_no_go